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ART. XXV.—*Notes on Physiological Optics.* No. 5. *Vision by the Light of the Electric Spark;* by W. LECONTE STEVENS.

IN previous papers the phenomena of optic divergence have been discussed, and also various peculiarities of vision under controllable physiological conditions. Among them was stereoscopy from a pair of perfectly similar figures, produced by so varying these in relative position that the retinal images of them were dissimilar. A geometric explanation of this was given, in which it was assumed that freedom of motion was allowed the eyes; but with the reservation that such motion is not necessary in obtaining the perception of binocular relief from stereographs constructed in the ordinary way, and that it was probably necessary only to the completeness of the perception in the present case when the dissimilarity of retinal images was very considerable.

In continuing this investigation the electric spark has been employed as a means of illuminating the pair of pictures. These were viewed with the aid of a reflecting stereoscope, already described as a device to indicate the value of the optic angle, positive or negative, that results from any possible relation between the visual lines of a pair of eyes. Vision may thus be made normal or abnormal at will. The use of the spark in the study of binocular vision is no novelty; but it seems not to have been employed hitherto in studying abnormal vision with the visual lines divergent, or the peculiar mode of stereoscopy recently devised.

The apparatus employed was a large induction coil, belong-

ing to the physical cabinet of Columbia College, the use of which was kindly granted by Professor O. N. Rood. In the secondary circuit a Leyden jar was interposed, and by means of a pair of lenses the light was separately converged upon each of the pair of pictures, strongly illuminating them momentarily in the dark room. Each picture was kept upon the pivoted arm of the stereoscope at a fixed distance from the oblique mirror that reflected its light into the eye of the observer. The sum of the incident and reflected rays from each to the receiving eye was, as nearly as possible, 25 cm.

The stereograph first employed was one of the moon, the same one formerly used with this instrument in vision by continuous light. By varying the arrangement of the cards the visual effect of binocular combination of images could be made that of either a convex surface, or concave surface, or an indistinct but flat surface. The observer placed himself with closed eyes in proper position before the stereoscope while the manipulator of the apparatus arranged the cards. He was then requested to interpret the combined retinal image produced by illuminating the cards with a single spark, not knowing previously whether to expect convexity, concavity, or flatness in the combined picture, and the interval of illumination being too brief for any possible play of the eyes.

In conducting these experiments I was so fortunate as to secure the coöperation of Mr. W. W. Share, assistant Professor of Physics in Columbia College, who soon acquired more than usual skill in the control of his eyes. Each of us acted successively as observer and as manipulator of the apparatus, the work being distributed through a number of days for the purpose of avoiding fatigue at any one sitting. When the relation between the visual lines was such as to imply no unusual muscular strain, each of us found it possible to interpret the binocular retinal image correctly by the light of a single spark. Many other stereographs were substituted in succession for that of the moon, and with similar results. Some of these consisted of heavy black lines on a white ground, others of white lines on a black ground; in some cases one picture belonged to one of these classes and its mate to the other. At the suggestion of Professor Rood a pair were constructed, one of which consisted of green lines on a red ground, the other of red lines on a green ground. In this case of complementary colors it was a little more difficult to attain a perfectly clear perception by a single spark, but when there was any uncertainty another spark after an interval of a second of time, was usually sufficient to resolve the doubt. These pictures were arranged to give stereoscopic relief, but the nature of this, whether direct or inverse, was what the observer had to determine.

Upon each arm of the stereoscope was now placed a vertical frame, pivoted centrally over a divided horizontal circle (fig. 1), so that the plane of the card that was fitted into it could be made to assume any desired angle (φ) with the direction of the arm. A pair of cards on which were similar series of concentric circles were then introduced, the arms being arranged for parallel vision, and the frames directly across them. The binocular resultant was of course a circular flat plane vertically across the combined line of sight. The manipulator then turned each frame on its pivot through an angle, whose nature, whether positive or negative, was unknown to the observer, and then passed a spark. For values of this angle less than 30° or 40°, the first spark was usually sufficient to enable the observer to determine whether the binocular resultant, due to opposite obliquity of projection upon the two concave retinas, was itself convex or concave. This was tried successively and independently by Professor Rood, Mr. Share, and the writer, with uniform results, the only difficulty consisting in the previous attainment of proper adjustment for the position of the head, and in adaptation of the ciliary muscles. For larger values of the angle between card and visual line, the degree of dissimilarity between the two retinal images sometimes caused a little confusion, but a few sparks, not in quick succession, were enough to clear all doubts. The diameter of the largest

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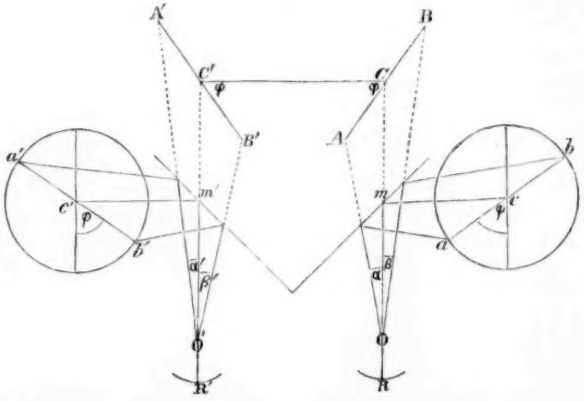

circle being 8 cm. and the sum of the incident and reflected rays from its center to the eye of the observer being 25 cm., it becomes possible to calculate the maximum difference horizontally between the two retinal images. Let m and m' (fig. 1) be the points of incidence for rays from the centers c and c', of the circles whose horizontal diameters are ab and $a'b'$, the cards

having been revolved each on a vertical axis through the angle φ. Then to the eyes whose nodal points are o and o', the pictures appear by reflection at A B and A′ B′, the visual lines oc and $o'c'$ being parallel and perpendicular to cc'. But if directed to A and A′ or B and B′, the visual lines become convergent to an extent measured by the difference of the angles α and α' or β and β'. The values of α and α' can be expressed in terms of the variable φ and the known quantities Ac and co, and we are thus enabled to find for what value of φ the difference, $\alpha-\alpha'$, becomes a maximum. For the values just assigned to Ac and oc, this condition is attained when $\varphi=52°$ 25′. By ordinary methods in trigonometry two sides and the included angle of each triangle being known, α and α' are then determined, and their difference found, which in the present case becomes 1° 25′ 37″. Assuming an average value, 15·75 mm. for the distance from nodal point, o, to retina, R, the linear horizontal displacement on the retina corresponding to 1° 25′ 37″ is a trifle over ·39 mm., or more than 80 times the diameter corresponding to what has been estimated to be the *minimum visibile*. For angles even smaller than 52° 25′ both Mr. Share and myself found it possible to detect double images at the margins of the binocular picture; this, however, did not prevent the perception of the particular kind of relief, whether concavity or convexity, which the arrangement necessitated. In trying the experiment by continuous light many persons have at first been confused, but a few moments of play of the eyes were enough to produce clear perceptions, and the form of the binocular image thenceforth remained distinct even when the gaze was kept as nearly rigid as possible. Unless there has been special training in binocular vision the duplication of these marginal images is rarely perceived at all.

On the other hand, to find the smallest retinal displacement through which change of form in the binocular image can be perceived in this manner, I have substituted series of circles in which the maximum diameter was only 4 cm., keeping the distance unchanged. The plane binocular image became noticeably concave for a rotation of each through only 1°. By calculation the angular retinal displacement is here found to be only 47″, an amount so small that under the most favorable circumstances no double image could be perceived with the acutest vision thus far tested. These experiments therefore tend to confirm the conclusion reached by Helmholtz,* in opposition to many other physiologists, that neither play of the eyes nor the perception of double images is indispensable to the attainment of binocular relief, however important these elements may sometimes be in confirming our visual judgments, whether con-

* Optique Physiologique, p. 1007, *et seq.*

scious or unconscious. They are exceedingly convenient for the purpose of explaining binocular vision, but so limited an explanation can never cover all the facts.

In 1864 Professor C. F. Himes described a pair of pictures which he had devised to illustrate the variation in apparent size of the moon when viewed successively at the horizon and the zenith. Within two equal circles, A and A′, fig. 2, are

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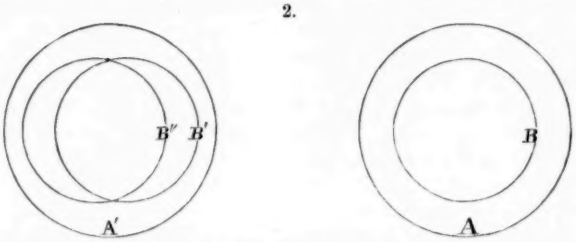


placed smaller circles, B, B′ and B″, the latter equal to each other. A and B are concentric, while the centers of B′ and B″ are on opposite sides of that of A′ and aligned with that of A. On combining the two pictures binocularly, A and A′ at once unite; B and B′ when united form a small circle whose plane is nearer, B and B″ one whose plane is farther than that of A and A′, assuming the union to be by diminished convergence of visual lines. The circle BB″ appears as much larger than BB′ as its distance is judged to be greater, despite the fact that the small circles are all of equal size. On the theory of double images, when BB′ is regarded, the circle B″ remains uncombined while AA′ should be seen double; the comparison of the nearer and more remote combinations being attained by regarding them successively. But in fact the appearance of the three circles, each at its proper distance, is instantaneous and simultaneous, not successive. If the observer's eyes are well trained the circle AA′ may be detected as double while the others are seen single. If the gaze be very rigidly fixed upon the center of the combined circle AA′, the others are separated, three small circles are seen, but all apparent variation in distance is lost. This stereograph has been examined under the light of the electric spark by both Mr. Share and myself, the results being entirely analogous to those obtained with continuous light. Each circle was appropriately marked and the cards adjusted by the manipulator in such manner that the observer could have no previous knowledge to aid him in determining which combined circle ought to appear nearest. A single spark was usually sufficient to show each in its appropriate place. The circle B has the same effect on B′ and B″ as if it were simultaneously combined with both of them. This

apparent combination of one line with two other lines at the same time was noticed by Professor W. B. Rogers in 1856 and further discussed by Helmholtz in 1867, but its bearing on the theory of binocular perspective has not received sufficient attention. It not only shows the insufficiency of the theory upheld by Brücke and Brewster, but also seems to indicate that, if there be any intuitive power of distinguishing between heteronymous and homonymous double images, this power must be understood to extend to cases in which a single line belongs to both kinds of double image at the same time. If we admit intuition at all in this connection, we must further grant that a distinction can thus be made instantly between these opposite kinds of images, even when they are so minute that the unaided eyes cannot separate them through an act of conscious judgment; and that this is habitually done by thousands who throughout life fail to suspect even the existence of such duplication in any part of the field of view. If there is any perception of double images, even when the interval between the components is wide, it is by an act of special attention. Many of our judgments, not only in vision but in the performance of other bodily functions, are instantaneous and unconscious; but probably we shall never be able to put an exact dividing line between those due to the experience of the individual and those that spring from tendencies transmitted by the race. We learn to see, just as we learn to walk or talk in infancy, by oft-repeated efforts which form a succession of experiences. If passive seeing be a result of mere inheritance, then active looking is superadded as a result of training. The empirical theory, if sufficient to explain all known facts of vision, can leave no room for intuition, and its resources must be exhausted before any resort to intuition can be deemed necessary.

To test the illusions of abnormal vision by the light of the electric spark, a series of experiments has been made in which the optic angle was varied from 3° of divergence to 50° of convergence of visual lines. The graduated reflecting stereoscope was employed, the mode of experiment being the same as that described in a former paper, the manipulator of the apparatus keeping the observer's record of estimates. Mr. Share and myself relieved each other by turns, taking care to avoid fatigue of the muscles of the eyes, each remaining ignorant of his own record until the entire series of experiments was completed. After the arms of the stereoscope had been arranged to necessitate a particular value of the optic angle, the observer opened his eyes, and, by the light of a slow succession of sparks, adjusted them to secure binocular vision of the stereograph of the moon, each picture of which was kept in a fixed position on the arm that carried it. The observer's

judgment of the distance and diameter of the combined image was then recorded. Eight estimates for each of thirteen values of the optic angle were made in irregular succession by each observer, the experiments being distributed through two weeks. On examination of the results attained, they were found not to differ materially from those published in a former paper by myself, as secured with continuous light. The limits of error were much wider, as might be expected, showing that any single judgment under such abnormal conditions has very little value; but that, even when there is little opportunity for play of the eyes, the effect of muscular strain on the internal rectus and ciliary muscles is to modify the unconscious interpretation of the retinal image, making the picture look much smaller and nearer but not necessarily at the intersection of visual lines. Mr. Share's judgments of distance and size were almost uniformly a little less than my own. In cases of optic divergence it was more difficult to secure the proper adjustment of visual lines than in those of convergence. Distinct vision was not attainable for divergence of more than $-3°$, though with slight indistinctness I found it possible to attain the perception of binocular relief for values as high as $-7°$. As a limit, therefore, $-3°$ was selected, and this was attained by both observers, through voluntary control of the oculo-motor muscles. Since divergence of visual lines is never necessary in ordinary vision, such adaptation of the eyes, if these be normal and not specially trained, requires usually two external points of fixation, and time becomes an element of more importance than when the coördination of muscular actions is such as habit has made easy.

ART. XXVI.—*On crystals of Monazite from Alexander County, North Carolina;* by EDWARD S. DANA.

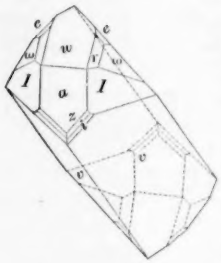
AMONG the results of the mineralogical investigations in North Carolina, by Mr. W. E. Hidden, one of the most interesting has been the discovery of the rare mineral monazite at a large number of localities. Mr. Hidden remarks* that at Milholland's Mill, Alexander County, he has found, in a vein in a garnetiferous mica schist, a large number of monazite crystals, together with fine geniculated crystals of rutile, quartz crystals, pseudomorphs of limonite after siderite, and muscovite, the last species making up the greater part of the vein. The monazite was obtained by the concentration of the loose material of the vein. Most of the crystals were very minute, of

* This Journal, III, xxii, pp. 21, 22, July, 1881.

several hundred perhaps only half a dozen exceeded $\frac{1}{20}$ inch in diameter; rarely crystals of $\frac{1}{4}$ inch in length were found. The crystals were highly modified, very brilliant in luster, of a rich topaz-yellow color, and perfectly transparent.

It is further stated by Mr. Hidden that he has found large crystals of monazite *in situ* in mica schist at the Deake mica mine in Mitchell County; one of these was $1\frac{1}{2}$ inches in length and $\frac{3}{4}$ inch in width. The same mineral occurs in white orthoclase at the Ray mica mine on Hurricane Mountain in Yancey County. He has also found it very commonly in the auriferous gravels of McDowel, Rutherford, Burke and Polk Counties. It is most abundant at J. C. Mill's gold mine in the Brindletown District, Burke County, "fifty pounds of gravel washings from this mine afforded sixty per cent of monazite." The crystals from this last locality have been analyzed by Mr. S. L. Penfield (see p. 251, in this number.)

A few of the best crystals of the monazite from Milholland's Mill, Alexander County, have been placed in the hands of the writer by Mr. Hidden; and one of these, much superior in luster to the others, has given an opportunity for a tolerably exact determination of the crystalline form. The crystals are generally prismatic (see figure) in habit through the elongation of the planes v (+1), and in this respect they are similar to a variety of the Russian mineral figured and described by von Kokscharof,* as also to crystals from Canton Tessin, Switzerland, described by Seligmann.†



The single crystal, which was subjected to careful measurement, was very brilliant in luster, and most of the planes, with the exception of those lettered v (+1) gave good reflections. The following planes were observed, all of which are common on ordinary monazite:

a	i-i	(100)	v	+1	($\bar{1}$11)
I	I	(110)	ω	−2-2	(121)
w	−1-i	(101)	i	+2-2	($\bar{2}$11)
e	1-i	(011)	z	+3-3	($\bar{3}$11)
r	−1	(111)			

In addition to the above, three other planes were observed, viz: ξ, replacing the edge ω/v (121, $\bar{1}$11); ψ, replacing the edge ω/v (121, 11$\bar{1}$); and φ replacing the edge r/e (111, 011). The measured angles ($\xi \wedge \omega = 44°$, $\psi \wedge \omega = 56°$, $\varphi \wedge e = 4\frac{1}{2}°$) were only rough approximations, so that no indices could be given to the planes with any degree of certainty.

* Min. Russland, iv, 17. † Zeitsch. Kryst., vi, 231, 1882.

The following fundamental angles (supplement) were measured with a Fuess goniometer provided with two telescopes, viz:

$a \wedge w$	$100 \wedge 101 = 39^\circ\ 12'\ 30''$
$I \wedge I$	$110 \wedge 1\bar{1}0 = 86^\circ\ 34'\ 20''$
$a \wedge e$	$100 \wedge 011 = 79^\circ\ 53'\ 3''$

Each of these is the mean of a considerable number of independent measurements, whose extremes varied not more than 30″ from the mean given. The axial ratio obtained from them may be regarded as reasonably exact, viz:—

$$c\ (\text{vert.}) : b : \dot{a} = 0{\cdot}95484 : 1{\cdot}03163 : 1.$$

$$\beta = 76^\circ\ 20'$$

The following table contains a list of the more important angles (supplement angles) calculated from the above data, and also such measured angles as could be obtained with sufficient accuracy to make them of interest. The agreement between the measured and calculated angles is close in the cases where the planes yielding the former gave good reflections, but the planes which give the prismatic habit to the crystals (*v*) afforded angles on which no dependence at all could be placed.

		Measured angles.	Calculated angles.
$a \wedge c$	$100 \wedge 001$	----	$76^\circ\ 20'$
$a \wedge I$	$100 \wedge 110$	$43^\circ\ 17'$	$43\ 17$
	$100 \wedge 1\bar{1}0$	$43\ 18$	
$a \wedge e$	$100 \wedge 011$	$79\ 53$*	$79\ 53$
$a \wedge w$	$100 \wedge 101$	$39\ 12\frac{1}{2}$*	$39\ 12\frac{1}{2}$
$a \wedge r$	$100 \wedge 111$	$47\ 55$ approx.	$48\ 1\frac{1}{2}$
$a \wedge v$	$100 \wedge 11\bar{1}$	----	$61\ 30\frac{1}{2}$
$a \wedge \omega$	$100 \wedge 121$	$59\ 50$	$59\ 48\frac{1}{2}$
$a \wedge i$	$100 \wedge 21\bar{1}$	----	$38\ 21$
$a \wedge z$	$100 \wedge 31\bar{1}$	$26\ 57$ approx.	$26\ 44$
$I \wedge c$	$110 \wedge 001$	----	$80\ 6$
$I \wedge e$	$110 \wedge 011$	$54\ 4$	$54\ 6$
$I \wedge w$	$110 \wedge 101$	$55\ 41\frac{1}{2}$	$55\ 40$
$I \wedge r$	$110 \wedge 111$	----	$33\ 35$
$I \wedge v$	$110 \wedge 11\bar{1}$	----	$40\ 50$
$I \wedge \omega$	$110 \wedge 121$	$27\ 25$	$27\ 25$
$I \wedge i$	$110 \wedge 21\bar{1}$	----	$30\ 42$
$I \wedge I$	$110 \wedge 1\bar{1}0$	$86\ 34$*	$86\ 34$
$e \wedge e$	$011 \wedge 0\bar{1}1$	----	$83\ 56$
$r \wedge r$	$111 \wedge 1\bar{1}1$	----	$60\ 40$
$v \wedge v$	$\bar{1}11 \wedge \bar{1}\bar{1}1$	$73\ 12$	$73\ 19$
$\omega \wedge \omega$	$121 \wedge 1\bar{2}1$	$99\ 0$	$98\ 58$
$i \wedge i$	$\bar{2}11 \wedge \bar{2}\bar{1}1$	----	$49\ 51$
$z \wedge z$	$\bar{3}11 \wedge \bar{3}\bar{1}1$	----	$35\ 35$
$w \wedge e$	$101 \wedge 011$	$53\ 38\frac{1}{2}$	$53\ 38\frac{1}{2}$
$w \wedge r$	$101 \wedge 111$	30 approx.	$30\ 20$
$w \wedge \omega$	$101 \wedge 121$	$49\ 31$	$49\ 29$
	$101 \wedge 1\bar{2}1$	$49\ 29$	
$e \wedge \omega$	$011 \wedge 121$	$26\ 39$	$26\ 41$

It is a matter of some interest to compare the axial dimensions of the Alexander County monazite with those of the same

mineral from other localities. The following table exhibits the relations.

	c (vert.)	b	$\dot{a}$	β
Alexander Co., N. C.	0·95484	1·03163	1·	76° 20′
Norwich, Mass., J. D. Dana, Syst. Min.	0·94715	1·0265	1·	76 14
Southern Ural, near R. Sanarka, N. von Kokscharof*	0·95010	1·03037	1·	76 14
Tavetsch, Switzerland (turnerite), G. vom Rath†	0·96166	1·04336	1·	77 18
Laacher See (turnerite), G. vom Rath‡	0·95425	1 03532	1·	76 32

* Min. Russl., iv, 5 et seq. † Pogg. Ann., cxix, 252, 1863.
‡ Pogg. Ann., Erg.-Bd., v, 413, 1871.

The same relation is more clearly brought out by comparing a few of the more important angles in the above cases, as also in some others.

	$a \wedge c$ $100 \wedge 001$	$a \wedge w$ $100 \wedge 101$	$a \wedge I$ $100 \wedge 110$	$a \wedge v$ $\bar{1}00 \wedge \bar{1}11$	$e \wedge e$ $011 \wedge 0\bar{1}0$	$v \wedge v$ $\bar{1}11 \wedge \bar{1}\bar{1}1$
Alexander Co., N. C.						
E. S. Dana	76° 20′	39° 12½′	43° 17′	61° 30½′	83° 56′	73° 19′
Norwich, Conn., J. D. Dana, Syst. Min.	76 14	39 20	43 25	61 47	83 44	73 24
Ural, N. v. Kokscharof*	76 14	39 16	43 18½	61 40½	83 42	73 16
Tavetsch (turnerite), G. vom Rath†	77 18	39 33	43 5	60 47½	83 56	72 32
Laacher See (turnerite), G. vom Rath (l. c.)	76 32	39 19½	43 12½	61 23½	83 45	73 1
Mont Sorel (turnerite), Des Cloizeaux	----	39 20	43 12	----	83 40	73 0

* l. c. and ib., vi, 200, 387. † l. c., also Jahrb. Min., 393, 1876.

In addition it may be stated that Trechmann* has found on monazite (turnerite) from Tavetsch, $a \wedge I = 43° 16′$, $c \wedge e = 84° 47′$; and for the same mineral from the Binnenthal, $a \wedge w = 40° 6′$, $e \wedge e = 85° 19′$, $v \wedge v = 72° 7½′$. On crystals from the Ilmen Mountains, von Jeremejef† obtained $a \wedge c = 76° 17′$.

ART. XXVII.—*On the Occurrence and Composition of some American varieties of Monazite;* by SAMUEL L. PENFIELD.

MY attention was first directed to the composition of monazite by Professor Brush, who placed in my hands a specimen of an unknown mineral collected by Mr. E. F. Sheldon at Pelton's Quarry, Portland, Conn. It was then suggested that it might prove to be microlite, because of its resemblance to the so-called altered microlite (in fact, monazite, see beyond), from Amelia County, Virginia, specimens of which had just arrived at New Haven. A short chemical examination of the Port-

* Jahrb. Min., 1876, 593.
† Verh. Min. Ges. St. Pet., II, xii, 287 (Zeitsch. Kryst., i, 398.)

land mineral proved, however, the presence of phosphoric acid, and the specimen was identified as monazite. Subsequently a complete chemical analysis was made, the results of which will be given farther on.

The mineral is of a cinnamon-brown color, of rather resinous luster, and shows one perfect cleavage. The specimen was somewhat cracked, and along the fractures showed some signs of alteration which did not, however, penetrate into the solid material. It was easy to obtain for analysis material showing none of this alteration and apparently homogeneous. The original weight of the specimen was three and one-half ounces. The specific gravity was found to be 5·20–5·25. After analyzing this specimen it seemed interesting to investigate another American monazite, and Professor E. S. Dana accordingly gave me a sample of the monazite sand obtained by Mr. W. E. Hidden* from the gold washings in the Brindletown district, Burke County, North Carolina. Almost one-half of the bulk of this sand is composed of resinous-looking monazite grains, from one-sixteenth to one-eighth of an inch in diameter, some showing numerous crystalline planes. Together with the monazite occur spinel, magnetite, garnet, brilliant crystals of zircon, a little quartz, and a few other minerals. The monazite is easily distinguished from the accompanying material, and by careful picking enough was soon obtained, apparently pure, for analysis. Care was taken to select only the larger grains and those of a uniform cinnamon-brown color. The specific gravity of the selected material amounted to 5·10. The analysis is given farther on.

About the time when the analyses of the specimens were completed, a letter was received by Professor Brush from Professor Wm. M. Fontaine, stating that specimens which had been sent up to New Haven as altered microlite, had proved by examination to be monazite.† In connection with my other analyses I thought that it would be interesting to add an analysis of this new variety. The material for analysis was from a specimen in the Yale College collection.

The material selected was perfectly pure as far as the eye could judge. The color and luster were the same as in the Portland specimen, but a little darker than that of most of the Virginia specimens which had been sent here. The analysis will be seen below; the silica and thoria were carefully deter-

* See this Journal, III, xxii, p. 22; also this number, p. 248.

† The monazite from this locality was first mentioned by König (Proc. Acad. Nat. Sci. Philad., 1882, 15), who gives an approximate analysis. Later, a complete analysis was published by F. P. Dunnington (Amer. Chem. Journ., iv, 138, 1882); he shows that excluding the ThO_2 and SiO_2 the remainder corresponds to a normal phosphate of the cerium metals, and suggest that the thorium may perhaps be present as orangite. The last-mentioned article was received by me after this article was in manuscript.

mined, the rest not being carried out in duplicate owing to want of time at my disposal.

Analyses.

1. Portland, Ct. Sp. Gr. 5·20–5·25.

	I.	II.	Mean.	Ratio.
P_2O_5	28·19	28·16	28·18	·199
Ce_2O_3	33·69	33·40	33·54	·188
$(La, Di)_2O_3$	28·15	28·51	28·33	
ThO_2	8·33	8·17	8·25	·031
SiO_2	1·57	1·77	1·67	·028
Ignition	·36	·38	·37	
	100·29	100·39	100·34	

Hence, $(Ce, La, Di)_2O_3 : P_2O_5 = 1·00 : 1·06 = 1 : 1$, and
$ThO_2 : SiO_2 = 1·00 : 0·90 = 1 : 1$

2. Burke Co., North Carolina. Sp. Gr. 5·10.

	I.	II.	III.	Mean.	Ratio.
P_2O_5	29·45	29·20	29·20	29·28	·206
Ce_2O_3	31·38	31·94	30·77	31·38	·190
$(La, Di)_2O_3$	30·67	30·80	31·17	30·88	
ThO_2	6·68	6·24	6·56	6·49	·025
SiO_2	1·40	----	----	1·40	·023
Ignition	·20	·20	----	·20	
	99·78			99·63	

Hence, $(Ce, La, Di)_2O_3 : P_2O_5 = 1·00 : 1·08 = 1 : 1$, and
$ThO_2 : SiO_2 = 1·00 : ·92 = 1 : 1$

3. Amelia Co., Virginia. Sp. Gr. 5·30.

	I.	II.	Mean.	Ratio
P_2O_5	26·12	----	26·12	·184
Ce_2O_3	29·89	----	29·89	·172
$(La, Di)_2O_3$	26·66	----	26·66	
ThO_2	14·07	14·39	14·23	·054
SiO_2	2·82	2·87	2·85	·048
Ignition	·67	----	·67	
	100·23		100·42	

Hence, $(Ce, La, Di)_2O_3 : P_2O_5 = 1·00 : 1·07 = 1 : 1$, and
$ThO_2 : SiO_2 = 1·00 : 0·88 = 1 : 1$

A glance at the ratios calculated for these analyses will show that in every case the ratio of $(Ce, La, Di)_2O_3 : P_2O_5 = 1 : 1$. This is the ratio required for a normal phosphate of the cerium metals, $R_2P_2O_8$. It may be added that Rammelsberg* has described and analyzed monazite, from Arendal, which contained no thoria, and agreed with this formula. It will also be seen that each analysis has afforded a certain amount of thoria and silica, and that these also are present in the ratio of 1 : 1, or that required by a normal thorium silicate. When it is considered that oxide of thorium is widely different in its

* ZS. G. Ges., xxix, 79, 1879.

chemical relations from the oxides of the cerium metals, and hence should not be present as an isomorphous replacement of them; and, moreover, that it is present in the above analyses in very different amounts, it will seem natural, from a chemical point of view, to assume that the thoria, often found in monazite, exists in the form of thorium silicate as an impurity.

A careful examination of the Portland mineral with a pocket lens revealed no signs of an impurity which could be identified as thorite, so that a more careful investigation was made. A thin section of the mineral was examined with the microscope; it showed small grains of a darker resinous substance scattered through the section, which are undoubtedly the mechanically mixed thorite. On the fragment of Virginia monazite, from which the material for analysis was obtained, a very little of a resinous-looking mineral could be seen, and a small fragment of this powdered and treated on a watch glass with hydrochloric acid gave evidence of a jelly. Further, two thin sections of this material were examined; both showed dark resinous particles scattered through the section. These were similar to those in the section of the Portland variety, but more abundant. One of these sections was moistened with hydrochloric acid, gently warmed, then carefully washed with water and again examined with the microscope. White blotches were seen to have taken the place of many of the resinous spots, and when a solution of fuchsin was poured over the section, and the excess gently washed away, the gelatinous silica retained the coloring matter. The monazite appeared wholly unattacked by the treatment with hydrochloric acid.

These observations prove beyond question the presence of thorium silicate in monazite, and thus substantiate the above chemical evidence. It is a curious fact that these two rare minerals should be associated in this way together, and it may be hoped that, with the material at our disposal in the United States, good specimens of this silicate of thoria may be found. A glance again at the analyses shows that water is present in small quantity, as indicated by the loss by ignition, and if this belongs to the thorium silicate it amounts to nearly one molecule of water to one of the silicate; this is, nearly, the proportion in which they are united in the minerals thorite and orangite, but their water content is questionable and the material at our disposal was too limited to warrant further speculations.

With reference to the method of analysis it may be stated that phosphoric acid was separated from the bases by fusion with sodium carbonate and extraction with water. Thoria was separated from the oxides of the cerium metals by obtaining all the mixed oxides, free from phosphoric acid, as normal

sulphates, dissolving in cold water, adding hyposulphate of soda, and boiling; the precipitated thoria was collected on a filter, washed, ignited and weighed (Hermann's method.)* The amount of cerium was arrived at by determining the excess of oxygen in CeO_2 over Ce_2O_3; this was obtained by dissolving the ignited oxides (free from thoria), in dilute sulphuric acid mixed with oxalic acid; the oxides dissolved and the higher oxide of cerium decomposed the oxalic acid, setting carbonic anhydride free, which was collected in potash bulbs and weighed. Silica was determined by decomposing the mineral with sulphuric acid, evaporating till fumes came off, soaking out with water and filtering.

A determination of sulphuric anhydride in a weighed quantity of the mixed sulphates of the cerium metals from the Portland variety gave for the joint molecular weight of the oxides 328·2, or a joint atomic weight of 140·1, which determination was used in the calculation of the three analyses. It may be stated that great care was taken to prove the identity of the thorium. Besides its giving all the reactions for that element, a weighed quantity of the oxide gave by conversion into sulphate an atomic weight of 238·5. This sulphate was not quite soluble in water, which readily accounts for the result being a trifle higher than that usually accepted for thoria. The atomic weight, 231·5, was used in calculating the analyses.

In closing I wish to express my thanks to Professors George J. Brush and E. S. Dana for kindly providing the material for carrying out this investigation.

Sheffield Scientific School, May 3, 1882.

Art. XXVIII.—*On Irregularities in the Amplitude of Oscillation of Pendulums;* by C. S. Peirce.

[Communicated by the authority of the Superintendent of the U. S. Coast and Geodetic Survey.]

The pendulum experiments conducted by me for the Coast Survey exhibit considerable differences in the rate of descent of the arc on different days. Mr. O. T. Sherman (this Journal, xxiv, 176) having suggested that this might be due to a periodic variation of the amplitude, I feel called upon to say, —what a study of my published observations will show,—that this supposition is inadmissible. For, in order to account, in this manner, for the observed discrepancies, it would be necessary to suppose a periodic variation too great to escape direct observation. In most of my observations, I have used an arc accurately divided into thousandths of the radius. The reading telescope has a sidereal magnifying power of from 60 to

* Journ. f. pr. Chem., xxxiii, 90.

150 diameters, and is usually placed at a distance of about fifteen feet. The observations are made by placing the wire of this telescope successively in coincidence with the different lines of the graduated arc, and accurately noting the moment at which the point of the pendulum is just bisected by the wire at the extremity of its swing. It would thus be quite impossible to overlook a variation of the amplitude amounting to one ten-thousandth of the radius, while that of the pendulum was, say one-thirtieth of the radius.

The motion of a pendulum upon a flexible support has two harmonic constituents. One of these has nearly the natural period of the pendulum, the other nearly the natural period of the oscillation of the support. If the amplitude of the second motion is sensible, an irregularity of the arc of oscillation, often of a plainly periodic character, will necessarily result. The ratio of the amplitude of the second harmonic motion to that of the first depends upon the manner in which the pendulum is started; and upon a very flexible stand it is easy to start the pendulum in such a way as to produce a considerable variation in the amplitude. But theory shows that if the pendulum be started by pushing it to one side by a force applied at the center of oscillation and then letting it go, the second harmonic constituent vanishes. Now, this is the manner in which I always endeavor to start a pendulum. That, in point of fact, the second harmonic constituent is insensible is shown by the fact that it hardly shows itself even in the oscillation of the support, where it is relatively many times larger than in that of the pendulum. The equations showing this are given in my paper appended to the report of the Stuttgart meeting of the International Geodetic Association.

Mr. Sherman deduces the consequences which would result from the motion of the support having a different period from that of the pendulum. But for the considerable number of supports that I have examined in this respect, the mean period of the oscillation of support and pendulum have been the same. This is proved by the fact that, however long the experiment is continued, the oscillations of the one and of the other appear to be synchronous. There may, it is true, be a portion of the motion of the stand which is not synchronous with the main part of the motion of the pendulum; but this circumstance will have no appreciable effect on the period of the pendulum, if the latter is properly started.

Of the periodic phenomena observed by Mr. Sherman, I can propose no explanation, because I am unacquainted with the details of his experiments. But similar phenomena might result from a faulty mode of starting a pendulum upon a very flexible support.

ART. XXIX.—*Stresses caused in the Interior of the Earth by the Weight of Continents and Mountains;* by G. H. DARWIN, F.R.S.*

THE existence of dry land proves that the earth's surface is not a figure of equilibrium appropriate for the diurnal rotation. Hence the interior of the earth must be in a state of stress, and as the land does not sink in, nor the sea-bed rise up, the materials of which the earth is made must be strong enough to bear this stress.

We are thus led to inquire how the stresses are distributed in the earth's mass, and what are their magnitudes. These points cannot be discussed without an hypothesis as to the interior constitution of the earth.

In this paper I have solved a problem of the kind indicated for the case of a homogeneous incompressible elastic sphere, and have applied the results to the case of the earth.

It may of course be urged that the earth is not such as this treatment postulates.

The view which was formerly generally held was that the earth consists of a solid crust floating on a molten nucleus. It has also been lately maintained by Dr. August Ritter, in a series of interesting papers, that the interior of the earth is gaseous.† A third opinion, contended for by Sir William Thomson, and of which I am myself an adherent, is that the earth throughout a solid of great rigidity; he explains the flow of lava from volcanoes either by the existence of liquid vesicles in the interior, or by the melting of solid matter, existing at high temperature and pressure, at points where diminution of pressure occurs.

There is another consideration, which is consistent with Sir William Thomson's view, and which was pointed out to me by

* This article is cited from the Philosophical Transactions for 1882, Part I. It is the second part only of Mr. Darwin's memoir and has the title "Summary and Discussion. The first part of the paper is entirely devoted to a mathematical investigation based on a well-known paper of Sir William Thomson's. References to the plates are, for the most part, omitted.

† Anwendung der mechanischen Wärmetheorie auf kosmologische Probleme. Carl Rümpler, Hannover, 1869. This is a reprint of six papers in Wiedemann's Annalen.

Dr. Ritter contends that the temperature in the interior of the planet is above the critical temperature and that of dissociation for all the constituents, so that they can only exist as gas. Data are wanting with regard to the mechanical properties of matter at, say 10,000° Fahr., and a pressure of many tons to the square inch. Is it not possible that such "gas" may have the density of mercury and the rigidity and tenacity of granite? Although such a conjectural "gaseous" solid might possess high rigidity, it almost certainly would have great compressibility: but it is proved in § 10 that the compressibility will make exceedingly little difference in the result of the present investigation excepting in the case of the second harmonic inequality.

Professor Stokes. It may be that underneath each continent there is a region of deficient density; then underneath this region there would be no excess of pressure.

For the present investigation it is to some extent a matter of indifference as to which of these views is correct, for if it is only the crust of the earth which possesses rigidity, or if Professor Stokes's suggestion of the regions of deficient density be correct, then the stresses in the crust or in the parts near the surface must be greater than those here computed—enormously greater if the crust be thin,* or if the region of deficient density be of no great thickness.

With regard to the property of incompressibility, which is here attributed to the elastic sphere, it appears from § 10 that even if we suppose the elastic solid to be *very* highly compressible, yet the results with regard to the internal stresses are almost the same as though it were incompressible. I think the hypothesis of great incompressibility is likely to be much nearer to the truth than is that of great compressibility. I shall, therefore, adhere to the supposition of infinite incompressibility, bearing in mind that even great compressibility would not much affect most of the results.

I take then a homogeneous incompressible elastic sphere and suppose it to have the power of gravitation and to be superficially corrugated. In consequence of mathematical difficulties the problem is here only solved for the particular class of surface inequalities called zonal harmonics, the nature of which will be explained below.

Before discussing the state of stress produced by these inequalities, it will be convenient to explain the proper mode of estimating the strength of an elastic solid under stress.

At any point in the interior of a stressed elastic solid there are three lines mutually at right angles, which are called the principal stress-axes. Inside the solid at the point in question imagine a small plane (say a square centimeter or inch), drawn perpendicular to one of the stress-axes; such a small plane will be called an inter-face.† The matter on one side of the ideal inter face might be removed without disturbing the equilibrium of the elastic solid, provided some proper force be applied to the inter-face; in other words, the matter on one side of an inter-face exerts a force on the matter on the other side. Now a stress-axis has the property that this force is parallel to the stress-axis to which the inter-face is perpendicular. Thus along a stress-axis the internal force is either purely a traction

* The evaluation of the stresses in a crust, with fluid beneath, would be tedious, but not more difficult than the present investigation. I may, perhaps, undertake this at some future time.

† This term is due to Professor James Thomson.

or purely a pressure. Treating pressures as negative tractions, we may say that at any point of a stressed elastic solid there are three mutually perpendicular directions along which the stresses are purely tractional. The traction which must be applied to an inter-face of a square centimeter in area, in order to maintain equilibrium when the matter on one side of the inter-face is removed, is called a principal stress, and is of course to be measured by grams weight per square centimeter.

If the three stresses be equal and negative the matter at the point in question is simply squeezed by hydrostatic pressure, and it is not likely that in a homogeneous solid any simple hydrostatic pressure, *absolutely* equal in all directions, would ever rupture the solid. The effect of the equality of the three stresses when they are positive and tractional is obscure, but at least physicists do not in general suppose that this is the cause of rupture when a solid breaks.

If the three principal stresses be unequal, one must of course be greatest and one least, and there is reason to suppose that tendency of the solid to rupture is to be measured by the difference between these principal stresses.

In one very simple case we know that this is so, for if we imagine a square bar, of which the section is a square centimeter, to be submitted to simple longitudinal tension, then two of the principal stresses are zero (namely, the stresses perpendicular to the faces of the rod), and the third is equal to the longitudinal traction. The traction under which the rod breaks is a measure of its strength, and this is equal to the difference of principal stresses.

If, at the same time, the rod were subjected to great hydrostatic pressure the breaking load would be very little, if at all affected; now the hydrostatic pressure subtracts the same quantity from all three principal stresses, but leaves the difference between the greatest and least principal stresses the same as before.

Difference of principal stresses may also be produced by crushing.

In this paper I call the difference between the greatest and least principal stresses the "stress-difference," and I say that, if calculation shows that the weight of a certain inequality on the surface of the earth will produce such and such stress-difference at such and such a place, then the matter at that place must be at least as strong as matter which will break when an equal stress-difference is produced by traction or crushing.

I shall usually estimate stress-difference by metric tonnes (a million grams), per square centimeter, or by British tons per square inch.

In Table VII, § 9,* are given the experimentally determined values of the breaking stress-difference for various substances. The table is divided into two parts, in the former of which the stress-difference was produced by tension, and in the latter by crushing. It is not necessary here to advert to the difference in meaning of the numbers given in the first column and those given in the two latter columns in the first half of the table.

The cases of wood and cast brass are the only ones where a comparison is possible between the two breaking stress-differences, as differently produced. It will be seen that the material is weaker for crushing than for tension. For the reasons given in that section, I am inclined to think that these tables rate the strength of the materials somewhat too highly for the purposes of this investigation. I conceive that the results derived from crushing are more appropriate for the present purpose than those derived from tension; and fortunately the results for various kinds of rocks seem to have been principally derived from crushing stresses.

This table will serve as a means of comparison with the numerical results derived below, so that we shall see, for example, whether or not at 500 miles from the surface the materials of the earth are as strong as granite.

We may now pass to the mathematical investigation. It

* This table of limiting stress-difference is as follows:

TABLE VII.—*Limiting stress-difference.*

Produced by tension.				Produced by crushing.		
Material.	Breaking stress-difference in metric ton'es per square centimeter.	Stress-difference at which permanent set begins in—		Material.	Breaking stress-difference in—	
		Met'ic tonnes per square centimeter.	British tons per square inch.		Met'c tonnes per square centimeter.	British tons per square inch.
Sheet lead	·23	·23	1·46	Strong red brick	·077	·49
Cast tin	·416	·417	2·64	Strong sandstone	·39	2·45
"	·325 (R)	--	2·06 (R)	(F) Strong limestone	·60	3·80
Wood (ash)	1·20	1·20	7·61	Marble	·39	2·45
Cast brass	1·27	1·27	8·05	Granite	·39 to ·77	2·45 to 4·91
" iron	·94 to 2·04	1·14 to 1·87	7·23 to 11·86	(F) Granite (Mount Sorel)	·905	5·74
Drawn copper	4·10	4·00	25·36	(F) Grauwacke	1·19	7·54
English steel pianoforte wire	23·62	23·56	149·6	Ash (along the grain)	·63	4·02
(R) Brick, cement	·020 to ·021	--	·125 to ·134	Cast brass	·73	4·60
(R) Glass	·66	--	1·20	Wrought iron	2·52 to 2·84	16 to 18
(R) Slate	·68 to ·90	--	4·3 to 5·7			

NOTE.—The second and third columns give the product of Young's modulus into greatest elastic extension, and this should give the greatest stress-difference when permanent set begins. Rankine does not give the data for this quantity, but the breaking stress-difference is given in both metric and British units, the latter being in the third column. In the second half of the table the results marked F are from Sir William Fairbairn's experiments.

appears therefrom that the distribution of stress-difference is quite independent of the absolute heights and depths of the inequalities. Although the questions of distribution and magnitude of the stresses are thus independent, it will, in general, be convenient to discuss them more or less simultaneously.

The problem has only been solved for the class of superficial inequalities called zonal harmonics, and their nature will now be explained.

A zonal harmonic consists of a series of undulations corrugating the surface in parallels of latitude with reference to some equator on the globe; the number of the undulations is estimated by the order of the harmonic. The harmonic of the second order is the most fundamental kind, and consists of a single undulation forming an elevation round the equator, and a pair of depressions at the poles of that equator; it may also be defined as an elliptic spheroid of revolution, and the absolute magnitude is measured by the ellipticity of the spheroid.

If the order of the harmonic be high, say 30 or 40, we have a regular series of mountain chains and intervening valleys running round the sphere in parallels of latitude.

For the sake of convenience I shall always speak as though the equator were a region of elevation, but the only effect of changing elevations into depressions, and *vice versa*, is to diametrically reverse the directions of all the stresses.

The harmonics of the orders 2, 6, 10, etc., have depressions at the poles of the sphere; those of orders 4, 8, 12, etc., have elevations at the pole.

The harmonic of the fourth order consists of an equatorial continent and a pair of circular polar continents, with an intervening depression. That of the sixth order consists of an equatorial continent and a pair of annular continents in latitudes (about) 60° on one and the other side of the equator. The eighth harmonic brings down these new annular continents to about latitude 45°, and adds a pair of polar continents; and so on.

By a continuation of this process the transition to the mountain chains and valleys is obvious.

In section five the case of the second harmonic is considered. As above explained, the sphere is deformed into a spheroid of revolution. The investigation also applies to the case of a rotating spheroid, such as the earth, with either more or less oblateness than is appropriate for the figure of equilibrium.

It is remarkable that the stress-difference is the same all over the surface. In the polar regions the stress-difference diminishes as we descend into the spheroid, and then increases again; in the equatorial regions it always increases as we descend. The maximum value is at the center, and there the stress-difference is eight times as great as at the surface.

If the elastic solid be highly compressible the stress-differences are not nearly so great as on the hypothesis of incompressibility. In all the other cases considered in this paper compressibility makes practically no difference in the results.

On evaluating the stress-difference, on the hypothesis of incompressibility, arising from given ellipticity in a spheroid of the size and density of the earth, it appears that if the excess or defect of ellipticity above or below the equilibrium value (namely, $\frac{1}{232}$ for the homogeneous earth), were $\frac{1}{1000}$, then the stress-difference at the center would be eight tons per square inch; and, accordingly, if the sphere were made of material as strong as brass it would be just on the point of rupture. Again, if the homogeneous earth, with ellipticity $\frac{1}{232}$, were to stop rotating, the central stress-difference would be 33 tons per square inch, and it would rupture if made of any material excepting the finest steel.

A rough calculation* will show that if the planet Mars has ellipticity $\frac{1}{80}$ (about twice the ellipticity on the hypothesis of homogeneity), the central stress-difference must be six tons per square inch. It was formerly supposed that the ellipticity of the planet was even greater than $\frac{1}{80}$, and even if the latest telescopic evidence had not been adverse to such a conclusion, we should feel bound to regard such supposed ellipticity with the greatest suspicion, in the face of the result just stated.

The state of internal stress of an elastic sphere under tide-generating forces is identical with that caused by ellipticity of figure.† Hence the investigation of § 5 gives the distribution of stress-difference caused in the earth by the moon's attraction.

Computation shows that the stress-difference at the surface, due to the lunar tide-generating forces, is 16 grams per square centimeter, and at the center eight times as much. These stresses are considerable, although very small compared with those due to terrestrial inequalities, as will appear below.

In § 6 the stresses produced by harmonic inequalities of high orders are considered. This is, in effect, the case in a series of parallel mountains and valleys, corrugating a mean level surface with an infinite series of parallel ridges and furrows. In this case compressibility makes absolutely no difference in the result, as shown in § 10.

It is found that the stress-difference depends only on the depth below the mean surface, and is independent of the position of the point considered with regard to ridge and furrow;

* The data for the calculation are, Ratio of terrestrial radius to Martian radius, 1·878. Ratio of Martian mass to terrestrial mass, ·1020. Whence ratio of Martian gravity to terrestrial gravity, ·3596. Central stress difference, due to ellipticity e, $996e$ tons per square inch. "Homogeneous" ellipticity of Mars, $\frac{1}{166}$; and $\frac{996}{166}$ equal to 6.

† This is subject to certain qualifications noticed in section five.

the direction of the stresses does, however, depend on this latter consideration.

The greatest stress-difference depends merely on the height and density of the mountains, and the depth at which it is reached merely on the distance from ridge to ridge, being $\frac{1}{6\cdot28}$ of it.

Numerical calculation shows that if we suppose a series of mountains whose crests are 4,000 meters, or about 13,000 feet, above the intermediate valley-bottoms, formed of rock of specific gravity 2·8, then the maximum stress-difference is 2·6 tons per square inch (about the tenacity of cast tin); also if the mountain chains are 314 miles apart the maximum stress difference is reached at 50 miles below the mean surface.

It may be necessary to warn the geologist that this investigation is approximate in a certain sense, for the results do not give the state of stress actually within the mountain prominences or near the surface in the valley bottoms. The solution will, however, be very nearly accurate at some five or six miles below the valley-bottoms. The solution shows that the stress-difference is *nil* at the mean surface, but it is obvious that both the mountain masses and the valley-bottoms are in some state of stress.

The mathematician will easily see that this imperfection arises because the problem really treated is that of an infinite elastic plane, subjected to simple harmonic tractions and pressures.

To find the state of stress actually within the mountain masses would probably be difficult.

The maximum stress-difference just found for the mountains and valleys obviously cannot be so great as that at the base of a vertical column of this rock, which has a section of a square inch, and is 4,000 meters high. The weight of such a column is 7·1 tons, and therefore the stress-difference at the base would be 7·1 tons per square inch. The maximum stress-difference computed above is 2·6, which is about three-eighths of 7·1 tons per square inch. Thus the support of the contiguous masses of rock, in the case just considered, serves as a relief to the rock to the extent of about five-eighths of the greatest possible stress-difference. This computation also gives a rough estimate of the stress-differences which must exist if the crust of the earth be thin. It is shown below that there is reason to suppose that the height from the crest to the bottom of the depression in such large undulations as those formed by Africa and America is about 6,000 meters. The weight of a similar column 6,000 meters high is nearly 11 tons.

In § 7 I take the cases of the even zonal harmonics from the second to the twelfth, but for all except the second harmonic only the equatorial region of the sphere is considered.

In § 8 I build up out of these six harmonics an isolated equatorial continent. The nature of the elevation is exhibited in Plate xx, fig. 5, in the curve marked "representation;" no notice need be now taken of the dotted curve. This curve exhibits a belt of elevation of about 15° of latitude, in semi-breadth, and the rest of the spheroid is, approximately, spherical. This kind of elevation requires the second as one of its harmonic constituents, and this harmonic means ellipticity of the whole globe. Now, it may perhaps be fairly contended that on the earth we have no such continent as would require a perceptible second harmonic constituent. I therefore give, in Plate xx, fig. 5, a second curve which represents an equatorial belt of elevation counterbalanced by a pair of polar continents in such a manner that there is no second harmonic constituent.

I have not attempted to trace the curves of equal stress-difference arising from these two kinds of elevation, but I believe that they will consist of a series of much elongated ovals, whose longer sides are approximately parallel with the surface of the globe, drawn about the maximum point in the interior of the sphere at the equator. The surfaces of equal stress-difference in the solid figure will thus be a number of flattened tubular surfaces one within the other.

At the equator, however, the law of variation of stress-difference is easy to evaluate, and Plate xx, fig. 6, shows the results graphically, the vertical ordinates representing stress-difference, and the horizontal the depths below the surface. The upper curve in Plate xx, fig. 6, corresponds with the "representation curve" of Plate xx, fig. 5, and the lower curve with the case where there is no second harmonic constituent.

The central stress-difference, which may be observed in the upper curve, results entirely from the presence of the second harmonic constituent in the corresponding equatorial belt of elevation.

The maximum stress-differences in these two cases occur at about 660 and 590 miles from the surface respectively.

We now come to perhaps the most difficult question with regard to the whole subject — namely, how to apply these results most justly to the case of the earth.

The question to a great extent turns on the magnitude and extent of the superficial inequalities in the earth. As the investigation deals with the larger inequalities, it will be proper to suppose the more accentuated features of ridges, peaks and holes to be smoothed out.

The stresses caused in the earth by deficiency of matter over the sea-beds are the same as though the seas were replaced by a layer of rock, having everywhere the thickness of about $\frac{1}{2}\frac{0}{7}\frac{2}{5}$ or nearly $\frac{4}{11}$ of the actual depths of sea.

The surface being partially smoothed and dried in this manner, we require to find an ellipsoid of revolution which shall intersect the corrugations in such a manner that the total volume above it shall be equal to the total volume below it.

Such a spheroid may be assumed to be the figure of equilibrium appropriate to the earth's diurnal rotation; if it departs from the equilibrium form by even a little, then we shall much underestimate the stress in the earth's interior by supposing it to be a form of equilibrium.

Professor Bruns has introduced the term "geoid" to express any one of the "level" surfaces in the neighborhood of the earth's surface, and he endeavors to form an estimate of the departure of the continental masses and sea-bottoms from some mean geoid.* From the geodesic point of view the conception is valuable, but such an estimate is scarcely what we require in the present case. The mean geoid itself will necessarily partake of the contortions of the solid earth's surface, even apart from disturbances caused by local inequalities of density, and thus it cannot be a figure of equilibrium.

Thus, even if we were to suppose that the solid earth was everywhere coincident with a geoid, which is far from being the case, a state of stress would still be produced in the interior of the earth.

An example of this sort of consideration is afforded by the geodesic results arrived at by Colonel Clarke, R.E.,† who finds that the ellipsoid which best satisfies geodesic measurement has three unequal axes, and that one equatorial semi-axis is 1,524 feet longer than the other. Now, such an ellipsoid as this, although not exactly one of Bruns' geoids, must be more nearly so than any spheroid of revolution; and yet this inequality (if really existent, and Colonel Clarke's own words do not express any very great confidence) must produce stress in the earth. Colonel Clarke's results show an ellipticity of the equator equal to $\frac{1}{13731}$, and this in the homogeneous elastic earth will be about equivalent to ellipticity $\frac{1}{270000}$; such ellipticity would produce a central stress-difference of $\frac{7698}{270000}$, or nearly one-third of a British ton per square inch.

From this discussion it may, I think, be fairly concluded that if we assume the sea-level as being the figure of equilibrium, and estimate the departures therefrom, we shall be well within the mark.

The average height of the continents is about 350 meters (1150 feet), and the average depth of the great oceans is, in round numbers, 5,000 meters (16,000 feet); but the latter data

* Die Figur der Erde. Von Dr. H. Bruns. Berlin. Stankiewicz, 1878.

† Phil. Mag., Aug., 1878.

is open to much uncertainty.* When the sea is solidified into rock the 5,000 meters of depth is reduced to 3,200 meters below the actual sea-level. Thus the average effective depression of sea-bed is about nine times as great as the average height of the land. I shall take it as exactly nine times as great, and put the depth as 3,150 meters; but it is of course to be admitted that perhaps eight and perhaps ten might be more correct factors.

In the analytical investigation of this paper the outlines of the vertical section of the continents and depressions are always sweeping curves of the harmonic type, and the magnitude of the elevations and depressions are estimated by the greatest heights and depths, measured from a mean surface which equally divides the two.

We have already supposed the outlines of continents and sea-beds to have been smoothed down into sweeping curves, which we may take as being, roughly speaking, of the harmonic type. The smoothing will have left the averages unaffected.

The averages are not, however, estimated from a mean spheroidal surface, but from one which is far distant from the mean.

The questions now to be determined are as follows: What is the proper greatest height and depression, estimated from a mean spheroid, which will bring out the above averages estimated from present sea-level, and what is the position of the mean spheroid with reference to the sea-level.

From the solution of the problem considered in the note below,† it appears that, if the continents and sea-beds have sections which are harmonic curves, then if we take,—

* In a previous paper, "Geological Changes, etc.," Phil. Trans., vol. 167, Part I, p. 295, I have endeavored to discuss this subject, and references to a few authorities will be found there.

† Conceive a series of straight harmonic undulations corrugating a mean horizontal surface, and suppose them to be flooded with water. This will represent fairly well the undulations on the dried earth, and the water-level will represent the sea-level.

Suppose that the average heights and depths of the parts above and below water are known, and that it is required to find the position of the mean horizontal surface with reference to the water level, and the height of the undulations measured from that mean surface.

Take an origin of co-ordinates in the water-level, the axis of x in the water-level and perpendicular to the undulations, and the axis of y measured upward. Let

$$y = h(\cos x - \cos a)$$

be the equation to the undulations.

The average height of the dry parts is clearly $\frac{1}{2a}\int_{-a}^{+a} y\,dx$ or $\frac{h}{a}(\sin a - a\cos a)$.

Similarly the average depth below water is

$$\frac{h}{\pi - a}[\sin(\pi - a) - (\pi - a)\cos(\pi - a)] \text{ or } \frac{h}{\pi - a}[\sin a + (\pi - a)\cos a]$$

The mean level bisecting elevations and depressions as 2,480 meters (8,150 feet) below the sea-level, and the greatest elevation and depression from that mean level as 3,009 meters (9,840 feet), it results that the *average* height of the land above sea-level is 350 meters, and the *average* depression of dried sea-bed is 3,150 meters.

It thus appears that 3,000 meters would be a proper greatest elevation and depression to assume for the harmonic analysis of this paper, if the earth were homogeneous. But as the density of superficial rocks is only a half of the mean density of the earth, I shall take 1500 meters as the greatest elevation and depression from the mean equilibrium spheroid of revolution.

It is proper here to note that the height of the undulations of elevation and depression in the zonal harmonic inequalities is considerably greater toward the poles than it is about the equator; it might, therefore, be maintained that by making 1500 meters the equatorial height we are taking too high an estimate. But the state of stress caused in the sphere at any point depends very much more on the height of the inequality in the neighborhood of a superficial point immediately over the point considered, than it does on the inequalities in remote parts of the sphere.

Now in all the inequalities, except the second harmonic, I have considered the state of stress in the equatorial region, and

If the latter average be p times as great as the former

$$ph \cos a \left(\frac{1}{a} \tan a - 1\right) = h \cos a \left(\frac{1}{\pi - a} \tan a + 1\right)$$

This is an equation for determining a.

Now I find that $a = 34° 30'$ gives $p = 8{\cdot}983$, which corresponds very nearly with $p = 9$ of the text above.

This value of a corresponds with an average equal to $\cdot 1165h$ for the height above water, and $1{\cdot}0469h$ for the depth below water. Now, if we put

$$1{\cdot}0469h = 3150 \text{ meters}$$

which gives $\cdot 1165h = 350$ meters, very nearly,

we have $h = 3009$ meters.

The depth below water-level of the mean level is $h \cos 34° 30'$, or 2480 meters.

The greatest height of the dry part above the water-level is 3009—2480, or 429 meters, and the greatest depth of the submerged part below water-level is 3009 + 2480, or 5489 meters.

[After the proof-sheets of this paper had been corrected, Professor Stokes pointed out to me that, according to Rigaud (Cam. Phil. Soc., vol. vi), the area of the land is about four-fifteenths of the whole area of the earth's surface. Now, in the ideal undulations we are here considering the area above water is about one-tenth of the whole area; hence in this respect the analogy is not satisfactory between these undulations and the terrestrial continents. If I have not considerably over-estimated the average depth of the sea (and I do not think that I have done so), the discrepancy must arise from the fact that actual continents and sea-beds do not present in section curves which conform to the harmonic type; there must also be a difference between corrugated spherical and plane surfaces.

The geological denudation of the land must, to some extent, render our continents flat-topped.—Added May 4, 1882.]

it will therefore, I think, be proper to adhere to the 1500 meters for the greatest height and depression.

We have next to consider what order of harmonic inequalities is most nearly analogous to the great terrestrial continents and oceans. The most obvious case to take is that of the two Americas and Africa with Europe. The average longitude of the Americas is between 60° and 80° W., and the average longitude of Africa is about 25° E., hence there is a difference of longitude of about a right-angle between the two masses. These two great continents would be more nearly represented by an harmonic of the sectorial class,* rather than by a zonal harmonic, nevertheless I think the solution for the zonal harmonic will be adequate for the present purpose.

Now it has been explained above that the harmonic of the fourth order represents an equatorial continent and a pair of polar continents. In the case of the fourth harmonic therefore there is a right angle of a great circle between contiguous continents. We may conclude from this that the large terrestrial inequalities are about equivalent to the harmonic of the fourth order.

Table V (*b*), § 7, gives the maximum stress-differences under the center of the equatorial elevation of the several zonal harmonics, the height of each being 1500 meters.† The point at which this maximum is reached is given in each case, and Plate xx, fig. 4, illustrates graphically the law of variation of stress-difference.

The second harmonic cannot be said to represent a continent, and the table shows that in each of the other cases the maximum stress-difference is very nearly four tons per square inch. The depths of the maximum point are of course very different in each case.

* The sectorial harmonic of the fourth order $\sin^4\theta \cos 4\phi$ would well represent these two great continents. It would fairly represent China and Australia, but would annihilate the Himalayan plateau, and place another great continent in mid-Pacific. It is not at all difficult to find the stress-difference under the center of a sectorial inequality, but to find it generally involves the solution of a cubic equation.

† The following is the table:

TABLE V (*b*).—*Maximum stress-differences due to harmonic continents and seas.*

Order of harmonic.	2	4	6	8	10	12
Max. stress-difference, in metric tonnes per sq. c.m. due to contin'ts 1500 meters high	·858	·633	·626	·625	·625	·625
Ditto in British tons per sq. inch, for same continents	5·43	4·01	3·97	3·96	3·96	3·96
Depth in British miles at which this stress is attained	Center of earth	1146	725	532	420	347

N. B.—The continents referred to are supposed to be of the earth's mean density and are equivalent to actual continents of double the height.

We have concluded above that Africa and America are about equivalent to an harmonic of the fourth order, hence it may be concluded that the stress-difference under those continents is a maximum at more than 1100 miles from the earth's surface, and there amounts to about four tons per square inch. A comparison with Table VII shows that marble would break under this stress, but that *strong* granite would stand.

The case of the isolated continent investigated in section eight appeared likely to prove the most interesting one, for the purpose of application to the case of the earth. But unfortunately I have found it difficult to arrive at a satisfactory conclusion as to the proper height to attribute to the continent.

The average height of the American continent is about 1100 feet above the sea, and the average depth of the Pacific Ocean about 15,000 feet. If the water of the Pacific be congealed into rock it will have an effective depth of 10,000 feet. The greatest height of the American continent above the bed of the dried Pacific when smoothed down must be fully 12,000 feet, or 3700 meters. The height of the great central Asian plateau above the average bed of the southern ocean (after drying) must be considerably more than this.

Now, in the application to the homogeneous planet the heights are to be halved to allow for the smaller density of surface rock. I therefore take 2,000 meters as the height of the top of the equatorial table-land above the remaining approximately spherical portion of the sphere.

The investigation of § 8 then shows that the equatorial table-land will give rise to a stress-difference of 4·1 tons per square inch at a depth of 660 miles; and that the equatorial table-land counterbalanced by the pair of polar continents (the second harmonic constituent being absent), gives a stress-difference of about 3·8 tons per square inch at a depth of 590 miles.

This estimate of stress-difference agrees in amount, with singular exactness, with that just found from the case of the fourth zonal harmonic, but the maximum is reached 400 or 500 miles nearer to the earth's surface.

I think there can be no doubt but that there *are* terrestrial inequalities of much greater breadth than that of my isolated continent; thus this investigation for the isolated continent will give a position for the maximum stress-difference too near the surface to correspond with the largest continents. On the other hand, I do not feel at all sure that I have not considerably under-estimated the height of such a comparatively narrow plateau.

In the present paper it has been impossible to take any notice of the stresses produced by the most fundamental

inequality on the earth's surface, because it depends essentially on heterogeneity of density.

It is well known that the earth may be divided into two hemispheres, one of which consists almost entirely of land, and the other of sea. If the south of England be taken as the pole of a hemisphere, it will be found that almost the whole of the land, excepting Australia, lies in that hemisphere, whilst the antipodal hemisphere consists almost entirely of sea. This proves that the center of gravity of the earth's mass is more remote from England than the center of figure of the solid globe.

A deformation of this kind is expressed by a surface harmonic of the first order, for such an harmonic is equivalent to a small displacement of the sphere as a whole, without true deformation.

Now if we consider the surface forces produced by such a deformation in a homogeneous sphere, we find, of course, that there is an unbalanced resultant force acting on the whole sphere in the direction diametrically opposed to that of the equivalent displacement of the whole sphere.

The fact that in the homogeneous sphere such an unbalanced force exists shows that in this case the problem is meaningless; it is, in fact, merely equivalent to a mischoice in the origin for the coördinates. But in the case of the earth such an inequality does exist, and the force referred to must of course be counterbalanced somehow. The balance can only be maintained by inequalities of density, which are necessarily unknown. The problem therefore apparently eludes mathematical treatment.

It is certain that so wide-spreading an inequality, even if not great in amount, must produce great stress within the globe. And just as the second harmonic produces a more even distribution of stress than the fourth, so it is likely that the first would produce a more even distribution than the second.

It is difficult to avoid the conclusion that the whole of the solid portion of the earth is in a sensible state of stress.

I would not, however, lay very much emphasis on this point because we are in such complete ignorance as to the manner in which the equilibrium of the solid part of the earth is maintained.

From this discussion it appears that if the earth be solid throughout, then at a thousand miles from the surface the material must be as strong as granite. If it be fluid or gaseous inside, and the crust a thousand miles thick, that crust must be stronger than granite, and if only two or three hundred miles in thickness much stronger than granite. This conclusion is obviously strongly confirmatory of Sir William Thomson's view that the earth is solid throughout.

ART. XXX.—*The Deerfield Dike and its Minerals;* by BEN. K. EMERSON, Professor of Geology in Amherst College.

PREHNITE.—*a. In fissures at Cheapside, south of the river.*—Prehnite occurs here most abundantly and always as the oldest mineral in the veins in which it appears. That the veins where it is absent have been filled at a later period and at a lower temperature is evident from the fact that in these the vein-walls are quite as fresh as the body of the rock, while in the prehnite veins the walls are deeply decomposed, often to a depth of several centimeters into a rusty vesicular mass, which has been filled with massive prehnite, forming a rock nearly as compact as the trap itself. Similarly many detached fragments of the trap have been thoroughly decomposed and in the same way filled with massive prehnite. Under the microscope the mineral is here seen to be made up of fibers variously matted and interlaced and intermingled with the remains of the trap, and much of it exactly resembles chlorastrolite. In other specimens the oldest layer of the mineral is jet-black to deep oil-green, polished and often slickensided and gashed, the color being due to the thorough impregnation of the prehnite with diabantite. The motion of the rock walls has also at times broken up the prehnite into sheets which are slipped over each other variously and re-cemented by prehnite. Wherever the mineral is hindered in its growth it shows a strong tendency to take on these fibrous forms which seems to me to depend upon a greater energy of the crystallizing force in the direction of the long horizontal axis; upon which depends also the curvature of the faces so common in the species. Generally these fibers are quite large, peculiarly rigid and in large numbers parallel to each other. In one slickensided piece the fibers of black prehnite, all straight and parallel and placed at a slight angle to the surface of the trap, seem as if combed into this position by the movement of the walls and being jet-black from enclosed diabantite, resemble in appearance seams of fibrous hornblende or chrysotile.

The fibers are, however, generally colorless, transparent and of a high satiny luster on the face *O*. They are apparently always elongated in the direction of the long horizontal axis and bounded by the planes *O*, $i\text{-}\bar{i}$, $i\text{-}\breve{i}$. At times the satiny luster is reflected from a large group of the needles at once, and they are seen when magnified to be in juxtaposition, and forming each group for itself an aggregrate crystal, the lines of junction being represented in the larger crystals by the striation parallel to the long axis. At times the little groups ran under and over each other, or joined at their ends under angles of 80°

and 100°, as if there were some trace of twinning on *I*, as in the spindle-shaped crystals described later. It seemed like a model of the complex striation seen in the latter.

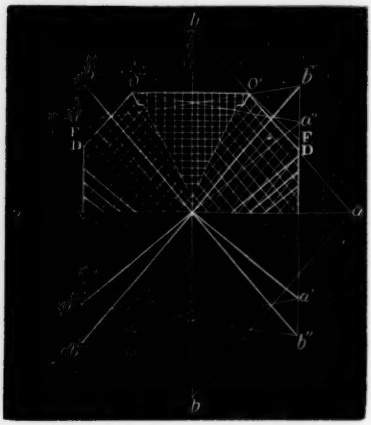
The prehnite also occurs in many drusy cavities covered with small distinct crystals, pale green, emerald-green to yellow, and in delicate emerald-green "roses" produced by the multiple twinning of the same form *O*, *i*-$\bar{i}$, *i*-$\breve{i}$, and in stout, square prisms with base and two sides convex, the two remaining sides concave. The more common botryoidal forms are scarcely represented.

By far the most abundant, finely-crystallized and peculiar form, is a stout double cone or spindle, the two cones joining directly base to base with an angle of 80°, or separated by a plane cylindrical, which may become as wide as the conical faces by which it is bounded; rarely this face is replaced by a reëntrant angle of 41°. These three faces are physically unlike, the two sloping ones being sometimes smooth and polished, at others mosaic-like, the equatorial plane being oftentimes milled as regularly as a coin, by the oscillatory repetition of *I* and *i*-$\breve{i}$; and finally the conical faces become rarely convex in the direction from the apex to the base, producing small globular forms. These cones are laid usually with their axes parallel to the surface on which they rest—the axes pointing in all directions in this plane—and fused together so that only a fraction of each one is distinct, though they often stand out so that half or three-quarters of the circumference is visible, and in this way completely cover broad surfaces with a splendid crystallization. In color, they range from white and nearly pellucid to pale celandine-green, and rarely to pale rose color in the smaller spindles with polished sides; to deep clear apple-green in the largest cones; and in other forms with very broad cylindrical faces, deep mountain-green. Several pieces a foot square were obtained covered with the finest crystals. In a single instance the crystals of this form have spread over calcite, and this having been removed, they presented a group of scarcely adhering individuals,—the segments of cones bounded below by a single, saddle-shaped face.

The internal structure of these crystals is quite peculiar. The pearly basal cleavage passes inward in the direction of a vertical section of the cone, and plates cut in this direction and continued down into the trap show the fibrous prehnite at the base felted together with much decomposed trap, above growing purer and forming distinct crystals, with doubly striated cleavage faces, which are twinned along a distinct suture and bounded outwardly by irregular planes of contact. After each crystal has risen above the general level to form the segment of a double cone, the suture forks with an angle of about 41°

and the two lines run to meet the angles formed by the meeting of the two conical faces, with the central zone. Each of the spindles is thus made up of three crystals, one on either side of, and one within, the angle of the Y-shaped suture.

1.



The shaded portion of figure 1 represents such a vertical section, in which $D\,o''$ and $D\,o$ $(=i\text{-}i)$ are the sections of the two conical faces and $o''\,o'$ $(=i\text{-}\breve{\imath})$ that of the central cylindrical face.

The relations of the three crystals are made clear by fig. 1. Three superimposed prisms (I) having the base (O) in common are revolved on the common vertical axis c to right and left until a prism face of each becomes parallel to the long horizontal axis of the third. Thus the two lateral crystals form an arrow-headed twin with a face of I in common, and are twinned against the middle one so that the same face (I) in each is parallel with $i\text{-}i$ of the latter. If now, the sharp angle of the two lateral forms be truncated by $i\text{-}i$, and that of the central one by $i\text{-}\breve{\imath}$, down to their point of contact o' and o, a plane, marked with a heavier line in the figure, results, by whose revolution on the short axis $a\text{-}a$, the spindle-shaped twin would be formed. The central crystal has the form of a triangular belt fitted into a similar groove upon the circumference of a wheel. An inspection of the figure will show that the arrow-headed twin, if formed by the union of two crystals having only the faces I and $i\text{-}\breve{\imath}$, would leave for the third crystal only an extremely shallow reëntrant angle of 160°, whereas the latter penetrates between the two in an angle of about 41°. This is because the obtuse angles of the lateral crystals are each replaced by the form $i\text{-}2\frac{1}{4}$, giving a reëntrant angle at x of 40° 57′ 6″. The approximated faces of this form are alone strongly developed and make a trumpet-shaped cavity for the reception of the wedge. The curved basal face in the free crystals mentioned above were formed by the blunt point of the arrow-head and by the corresponding faces of $i\text{-}2\frac{1}{4}$ on the outer obtuse angles below at a'' and a'. The tendency of the mineral to form these strange triplets seems to depend upon the greater intensity of the crystallizing force in the direction

of the long horizontal axis, so that of the many crystals which start in the fibrous base, only a few survive and grow up into the free space by preponderating additions to the face i-$\check{\imath}$ at right angles to the long axis, and are soon twinned so as to allow a third crystal to wedge in between them and grow by the development of the same face. All three grow thus predominantly in the same direction and expose and add to only the single crystalline face, and the crystal expands in growing like the top of a growing tree. The common vertical axis of the three crystals is bent thus into a circle.

When examined under the polarizing microscope, the central crystal, though showing a strong vertical and a faint horizontal striation, acts as a single crystal. The two flanking crystals present through a whole revolution under the Nicols a complex lattice-work of brilliant colors with two predominant positions of maximum extinction, or rather of extinction of the greatest number of the narrow bands and wedges of color in the field, at angles of 40° and 50° on either side of the suture; that is, when parallel to the two sets of axes a', b', and a'' b'' of the two lateral crystals. The narrow wedges of color often repeated many times, placed parallel to each other, extinguishing the light together and bounded by lines making an angle of 10° with each other, are especially peculiar.

Of course the extinction of the light on the right hand of the suture parallel to the axis a'' can alone be referred to the right hand crystal, and the extinction at an angle of 10° with this and on the same side of the suture, that is parallel to the axis of the left-hand crystal, must be referred to this latter. So that the twin is not formed simply by the approximation of the two parts along the common suture plane, but by the interpenetration also of each by the other in narrow, and, as it were, interwoven bands, as is represented schematically in the figure —much more regularly, of course, than in nature.

The two principal striations in the lateral prisms make an angle of 40° with the central suture—that is, an angle of 80° with each other.

It follows, taking the prism on the right (fig. 2) for example, that while one of these striations is parallel to the long axis b' of this prism, the other is parallel to the long axis b'' of the opposite, and in fact both striations seem in the plainest manner to be continuous as right lines across the suture.

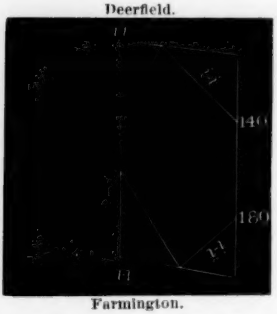
Traces exist also, very faint indeed, of two other sets of striations at right angles respectively to those already described, which are identical with the delicate horizontal lining of the central crystal, and which combined with those first described produce the long wedge-shaped blades with angle of 10° described above. This second striation is indicated in the

lower portion of the shading in fig. 1. The phenomena here detailed would seem also to find their explanation in the interpenetration of the lateral prisms.

The similar twins of prehnite from Farmington, Conn., which occur in the same triassic trap as the Deerfield crystals, were described by M. DesCloizeaux,* and have been recently the subject of discussion by the same author † and by M. Mallard ‡ because of their optical peculiarities. They do not seem from the descriptions to present the spindle shape described above, and in cross-section they differ from the Deerfield crystals in one important particular.

In the Farmington crystals the sloping faces (*F* in fig. 1) make an angle of 100° with each other, and the termination of the crystal is thus bounded by a threefold repetition of the face $i\text{-}\breve{i}$, while in the Deerfield forms the corresponding angle of the two sloping faces measured over the single exposed face of the central crystal is 80° (*DbD*, fig. 1), and the three faces have the formulæ $i\text{-}i$, $i\text{-}\breve{i}$, $i\text{-}\dot{i}$.

2.



One may express the relation of the two very simply by saying that in the Farmington crystals the end of the arrow-headed twin having the re-entrant angle has its acute angles truncated by $i\text{-}\breve{i}$ to form the sloping sides, while in the Deerfield forms the other end is developed, and the outer obtuse angles truncated by $i\text{-}i$, as in the annexed figure.

It seems to me simpler to say that the interpenetration of the two is so complex and at the same time so varying that in one case on the right of the suture the crystal which is turned to the right predominates and is truncated by $i\text{-}\breve{i}$ (*F* in fig. 1), and in the other that which at right angles to b' is turned to the left predominates on the same (the right) side, and determines the truncation by $i\text{-}i$ (*D* in fig. 1), at right angles to axis a''; while in the forms curved in the direction $o'\ a$, and in those with facetted faces there is a gradual or interrupted transition from the one to the other.

This would also harmonize very well with the complex optical results detailed in the above papers, and especially with the *dispersion tournante* signalized by M. DesCloizeaux for the Farmington crystals.

If the sloping faces in the Deerfield crystals like those of the

* Min., p. 451, Atlas XXIX, 167 bis, 1862.

† Bul. Soc. Min., vol. v, No. 2 and No. 5, 1882. ‡ Ibid., No. 3.

Farmington be referred to the acute angles of the arrow-head, to recur to the first explanation given above, they would have the more complex formula i–$6\frac{3}{4}$. Furthermore, the two well-marked striations described above form by their intersections diamonds with the acute angles (80°) at top and bottom, while the larger angle is at the sides, while the drawing of M. Des-Cloizeaux * shows the reverse to be the case in the crystals from Farmington.

That is, in the first they are parallel to b' and b'' (fig. 1), while in the second case, if they were exactly the reverse, they would be parallel to the short axes a' and a''; but they are stated in the later article of M. DesCloizeaux to make an angle not of 80° but of 82° with each other, so that while one is parallel to a short axis, the other is parallel to a hypothetical face, i-6. If they made an angle of exactly 80° with each other, they would represent the horizontal striation of the central crystal and the faint second striation described in the Deerfield crystals as slightly indicated at the bottom of figure 1. As it is they are difficult of explanation.

b. In amygdaloidal cavities.—The amygdules of the trap quite closely repeat in miniature the occurrences of the large fissures, but the peculiar changes the prehnite undergoes in the former case makes it needful to discuss separately its modes of appearance there.

In the coarse diabase it occurs compact, of a bright green, as if colored by copper. The paragenesis is (1) diabantite, (2) chalcopyrite, pyrite, galena, prehnite, one or all, (3) calcite.

In the red diabase, so abundant in the upper part of the dyke through Greenfield and Gill it appears in spherical and spheroidal balls 12–15^{mm} in diameter, very fine-fibrous and satiny, and very pale green to colorless; coated, and for a distance in impregnated with diabantite. It is radiated fine-fibrous, the fibers not easily separated, and diverging from several centers and meeting along sharp suture lines, so that only parts of spheres result, and if water-worn the grains would form perfect chlorastrolites.

In the dark gray diabase from the north side of the Deerfield and on through Greenfield and Gill, cavities 10–35^{mm} across are sometimes filled with fibrous prehnite, the whole blackened as if it had been held in the flame of a candle. Under the microscope the fibers are, for the most part, perfectly fresh, and up through the spaces between them has penetrated a black amorphous powder looking like the beard of iron filings on a magnet, or like a network of soot-covered cobwebs. The whole seems to be dendritic in character.

* Min., loc. cit.

PRODUCTS OF THE DECOMPOSITION OF PREHNITE. *Chlorophæite* (of Hitchcock.)—The mineral, chlorophæite, described by Macculloch in 1825, but not analyzed, proves now, from the analysis of Heddle,* to be of very different composition from the highly hydrated protoxide of iron silicate analyzed by Forchhammer, with which it has been associated. It is a magnesian peroxide of iron silicate with about 25 per cent of water, sometimes aluminous, and it approaches thus much more nearly to diabantite, from which it differs mainly in the peroxidation of the iron and in containing double the quantity of water.

In 1825 Pres. Hitchcock discovered a mineral "in the trap rocks about Turner's Falls, in Gill, Mass.,† which Professor J. W. Webster, of Harvard University, pronounced to be the chlorophæite of Macculloch," and the description given by Pres. Hitchcock agrees so exactly with that of Macculloch and Heddle, and the rapid blackening of the mineral is so peculiar, that the reference was very natural, and, I think, correct.

On examining slides of the "smoked" prehnite last described, its radiated needles were in the center colorless and perfectly fresh, and contained in abundance scales of diabantite with remarkably strong dichroism, brown-green to black. Although the smoky-black mass resembled closely an amygdule of the chlorophæite its great hardness and the crystalline surface proved it to be prehnite, and the peculiar striation dependent upon the arrow-head twinning was quite as characteristic. Toward the outer surface, however, the mass softened rapidly and could be readily impressed by the finger-nail, and under the microscope the fibers were seen to change quite rapidly into an amorphous or finely scaly material of red-brown color, showing faint aggregate polarization, but no dichroism. Farther in among the clear needles portions of the mass have all the needles likewise stained brown superficially. On examining the original specimens of President Hitchcock, No. 91, of the last catalogue of the Massachusetts State collection,‡ it was found to be distinctly radiated from several centers, the fibers of the same size and arrangement as those of the fine fibrous prehnite described *ante* p. (275), and a fragment broken from the specimen gave a pale-green powder and scratched apatite without difficulty. The cavity in which it is found is lined first with the foliated diabantite, then follows inwardly chalcopyrite, chlorophæite, the latter occupying thus the same place as the prehnite in the unaltered nodules. Under the microscope traces of the bright quartz-like polar-

* Trans. Roy. Soc. Edin., xxix, 84.

† This Journ., x, 393.

‡ State Board of Agricult. Report, vi, Appendix, p. lvi, where the mineral is misprinted chlorophocite.

ization and the peculiar striation of prehnite could be clearly seen. The latter mineral was, however, for the most part changed into a red-brown indistinctly scaly mass, with very faint polarization. The fibers of the original prehnite had not been at all fused together or changed in their relation to each other, and nothing was interposed among them. Other nodules completely changed showed also the network of black material between the needles. In specimen No. 92 of the same collection with H. 1·5, the fibrous structure is much less distinct than in the former one, both are of the same dull black color, but under the microscope it is seen to be made up of the same faintly scaly red-brown material arranged in radiated needles exactly as before, but now showing no trace of the further presence of unchanged prehnite. The brown material is not to be distinguished under the microscope from that which results from the change of diabantite, except that in each case the structure of the original mineral is retained.

In other cases the change of the prehnite has taken another course. In the variety from the new cutting at Cheapside described on page (270), where the lustrous bars of the mineral are interwoven with minute green fluor, the bars change toward the side where the fissure in which they were formed opened into the main vein, gradually into a pale green scaly mass which retains for a distance the shape of the bars and their relation to the fluor, but farther on is blended into a pale green mass with satiny luster, which looks as if it had been worked up into a paste and dried in a thin layer upon the surface. Similar masses are found abundantly, especially in the datolite, and under the microscope contain still fragments of fresh, unchanged prehnite. The mineral itself is under the microscope seen to be made up of loosely aggregated scales and to show a bright green color and a dichroism, both like that of diabantite. It is apparently hexagonal, many scales remaining black during a complete revolution between Nicols. Its lighter color seems to be the result of its different aggregation, and the powder of both is of the same light green. Prehnite can thus change into a mineral very similar to if not identical with diabantite (enough pure material for an analysis could not be obtained), and both the prehnite and the common scaly-radiated diabantite change into red-brown almost amorphous materials which cannot be distinguished microscopically.

I have assumed on what seems good grounds that the diabantite which fills the fibrous prehnite so often was formed at the same time with the latter, and it often shows a zonal arrangement in the prehnite which goes far to show that this was so, and in the specimens the two cases* can be easily dis-

* That of the diabantite originally enclosed in the fresh prehnite and the similar scaly mineral formed by the decomposition of the latter.

tinguished. On the other hand I think the change of the prehnite is primarily into the green diabantite-like mineral and through this into the brown peroxidized substance, and that the instability of the first or protoxide stadium of the substance is the condition of its rapid change from green to brown or black when exposed to the air. Indeed, this is also a striking characteristic of the common diabantite itself, and fresh trap specimens lose their green tint and soon turn brownish-black if exposed to the weather, though the change does not occur with such remarkable rapidity as is the case with the prehnite-diabantite or chlorophæite. Professor Heddle explains the sudden change of color by shrinkage-cracking due to partial dehydration.*

[To be continued.]

ART. XXXI.—*Note on the Occurrence of Siphonotreta Scotica*, Davidson, *in the Utica Formation near Ottawa, Ontario;* by J. F. WHITEAVES.

IN the spring of 1881, three specimens of a remarkable spinose brachiopod were collected by Mr. J. W. H. Watts, R.C.A., from a band of impure limestone in the Utica Slate at Cumming's Bridge, near Ottawa. These specimens, which Mr. Watts has since presented to the Museum of the Geological Survey of Canada, consist of two perfect examples of the beaked and perforated valve, which is probably the ventral, and of one detached dorsal valve in which the beak is obsolete. Over most of the central area of the sides of the valves the spines are broken off, and where this is the case the surface is marked with pitted imbricating concentric lamellæ, the pits representing the fractured bases of the spines. In each case the margins of the valves are densely fringed with a single and continuous row of fine hair-like spines, except immediately upon the beaks.

Upon examination with an ordinary simple lens it was at once apparent that these specimens are referable to DeVernueil's genus *Siphonotreta*, and that in most respects they bear a very close resemblance to an English species, the *S. Anglica* of Professor Morris. But the spines of *S. Anglica* are distinctly stated to be annulated, whereas those of the Canadian specimens appeared perfectly smooth when viewed under an achromatic microscope with an inch and a half objective.

A few months ago the writer had occasion to send some Canadian fossil Brachiopoda to Mr. Thomas Davidson, F.R.S.,

* Loc. cit.

for examination and comparison with British species. In the parcel forwarded the three examples of the *Siphonotreta* from Cumming's Bridge were included, and in a letter received from Mr. Davidson in May last they are reported upon as follows:

"The *Siphonotreta* from near Ottawa interests me much. It is identical in shape and characters with the Upper Llandeilo species which I named *Siphonotreta Scotica*. I am very uncertain whether the Wenlock Shale species named *S. Anglica* by Morris is the same or not. Only one crushed specimen of the *S. Anglica* has been found, and its spines are annulated as described by Morris. I could see no annulations in the spines of the many specimens of *S. Scotica* found by Mrs. Gray in the Upper Llandeilo of Craighead, nor do I see any in your specimens. As there is uncertainty as to the specific identity of the highest Upper Silurian form with the Lower Silurian one, and as none have been found in all that mass of intervening strata, I prefer provisionally to retain the two names, or until other Upper Silurian species shall have been found."

S. Scotica was originally described and figured in the Geological Magazine for January, 1877, and if the Canadian specimens are specifically identical with those from Scotland, the species must have had a considerable range in time, for the Upper Llandeilo rocks are generally regarded as of about the same age as the Chazy Limestone of the State of New York, and the Utica Slate as corresponding to beds on a comparatively high horizon in the Caradoc or Bala Group. To the paleontologist, Mr. Watts' discovery will be of special interest, as this is the first time that the occurrence of a species of *Siphonotreta* in North America has been placed upon record.

ART. XXXII.—*On a recent species of Heteropora from the Strait of Juan de Fuca;* by J. F. WHITEAVES.

THE genus *Heteropora* was constituted by DeBlainville in 1830 for the reception of a number of fossil species of Polyzoa of the order Cyclostomata, whose characters are thus defined by Busk: "Polyzoarium erect, cylindrical, undivided or branched; surface even, furnished with openings of two kinds; the larger representing the *orifices* of the cells, and the smaller the *ostioles* of the interstitial canals or tubes." "The essential character of the genus," writes Dr. H. A. Nicholson, "is thus the possession of a skeleton made up of two kinds of tubes, larger and smaller, the latter being the most numerous." Further, it has been ascertained that the tubes of *Heteropora* are provided with cross partitions and radiating spines, and that their walls are

perforated by numerous openings. These structures have been held to be the homologues of the tabulæ and septa of the tabulate corals, and of the mural pores of the Favositidæ. Lindström, in 1876, maintained that the Paleozoic fossils known to geologists as *Chætetes*, *Stenopora* and *Monticulipora* have almost exactly the same kind of internal structure as *Heteropora*, and consequently that the former genera should be removed from the class Anthozoa, to which the true corals are supposed to belong, and placed with the Polyzoa,—a conclusion which had been arrived at ten years before by Dr. Rominger.

Many species of *Heteropora* have been described from the Mesozoic and Tertiary rocks of Europe and the United States, but no living representative of the genus had been discovered until 1879. In that year Mr. Waters described and figured a recent species from Japan under the name *H. pelliculata*, in the Journal of the Royal Microscopical Society; and a little later in the same year, in the Journal of the Linnæan Society, Mr. Busk published a diagnosis, accompanied by illustrations, of a living polyzoon from New Zealand, which he called *H. Neozelanica*. Mr. Waters and Dr. H. A. Nicholson, however, have both expressed the opinion that the *H. Neozelanica* of Busk is identical with the previously described *H. pelliculata*.

On the coast west of Sooke, Vancouver Island, in the Strait of Juan de Fuca, Mr. James Richardson, late of the Geological Survey of Canada, found a single specimen of a recent polyzoon, in 1874, which, in the writer's judgment, cannot be distinguished by any tangible character from the Japanese and New Zealand species of *Heteropora* described by Messrs. Waters and Busk. No thin sections of this specimen have been made to show the minute structures of the interior, but the whole of the outer surface has been carefully examined under the microscope, and camera drawings of some of the most striking appearances thus presented have been made. The punctured, calcareous pellicle which Mr. Waters represents as closing the mouths of the interstitial canals in *H. pelliculata*, the character which suggested that specific name, can be well seen in part of the Canadian specimen. The general shape of the polyzoary of the latter and the microscopical characters of other portions of the surface agree perfectly with Busk's figures of the corresponding parts of *H. Neozelanica*. In one portion of the surface of the Fuca polyzoon it was noticed that the apertures of some of the larger tubes project distinctly beyond the general level, a feature not specially indicated in any of Messrs. Waters' or Busk's illustrations, but this slight variation from their types can scarcely be held as indicative of a specific difference from them.

ART. XXXIII.—*Communications from the U. S. Geological Survey, Rocky Mountain Division.* II. *Notes on some interesting Minerals occurring near Pike's Peak, Colorado;* by WHITMAN CROSS and W. F. HILLEBRAND.

THE region about Pike's Peak, in El Paso County, Colorado, has, within the past few years, become well known to mineralogists the world over through the large and perfect crystals of Amazon stone (microcline), which have found their way into almost every collection of importance, in Europe as well as in America. Other minerals, for the most part associated with the Amazon stone in occurrence, have also come into circulation to a less extent. The following minerals have been announced from this region, and are all authentic, viz: microcline, albite, biotite, quartz (smoky and clear), fluorite, columbite, göthite, hematite and limonite (pseudomorph after siderite), arfvedsonite, astrophyllite and zircon.

With but one or two exceptions the minerals named occur in "cavities" or "pockets" in granite, and although large quantities of some of the species have been found there is scarcely a mineral locality which at first sight seems more unpromising than this. The coarse reddish granite of the district disintegrates rapidly through the action of the weather into a coarse, gravel-like mass, and many of the mountain slopes are made of such material, lying at a very steep angle, with solid rock projecting through it here and there. On finding fragments of crystals in the debris, the prospector for minerals, with pick and shovel in hand, endeavors to find the original cavity from which the fragments came. The "cavities" are very irregular in shape and size, and yield varying quantities of crystals. A single cavity has been known to yield more than a ton of crystallized specimens. All so far discovered have been on the surface. That a direct connection exists between the tendency of the granite to disintegrate so readily, the formation of the cavities, and the deposition of these various minerals in them, can hardly be doubted.

Quite recently several occurrences of minerals, new to this region, have come to our notice, and are thought worthy of description. We can add to the above list of minerals, topaz, phenacite, cryolite, thomsenolite, and others not yet fully determined.

The phenacite and topaz were found about two years ago by Mr. Thebaut, a prospector of Colorado Springs, associated with feldspar, smoky quartz and zircon, in one of the "pockets" described. A crystal of phenacite came into the hands of Rev. R. T. Cross, of West Denver, to whom we are indebted

for calling our attention to it, and for aid in procuring other of the specimens here to be described.

Topaz.

Three crystals of topaz have been examined, all of them remarkable for size and clearness.

The most perfect one measures 2·5^{cm} parallel to the vertical axis, 3·3^{cm} parallel to the brachy-axis, and 2·8^{cm} parallel to the macro-axis. It is colorless, and some parts of the crystal are very clear. The prisms I (∞P) and i-2 ($\infty P2$) are well developed. The terminations are drusy, although many of the prominences are large enough to admit of the determination of some of the faces which bound them. The pyramid 2 ($2P$) has been recognized with certainty, while a form between $\frac{2}{3}$ ($\frac{2}{3}P$) and 1 (P), which is probably $\frac{4}{5}$ ($\frac{4}{5}P$), and another pyramid near 2–4 ($2P4$) are also present. Measurements of sufficient accuracy for the calculation of these latter forms could not be obtained. The lateral edges of these pyramidal prominences lie in a plane corresponding to the brachydome 2-i ($2P\infty$), and although that form does not actually appear, the crystal has a domatic habitus. A rough face of 4-i ($4P\infty$) is present quite distinctly. While one termination is more perfect than the other, both are alike.

The second crystal is less perfect. The prism i-2 ($\infty P2$) predominates, and the terminations are low and indistinctly drusy. The crystal measures 5^{cm} parallel to the macro-diagonal, and has a slight greenish tinge.

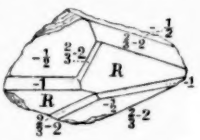
The third crystal, or rather fragment, was found recently near Florissant, northwest from Pike's Peak, with Amazon stone, etc. It is mainly noteworthy on account of the enormous size of the original crystal from which it came. This specimen is but a corner of a large crystal, the forms appearing being two faces of i-2 ($\infty P2$), one of I (∞P), and one each of 2-i and 4-i. The fragment is about 9^{cm} (3½ in.), in its longest diameter, and if the other faces were developed to correspond to those here seen, the complete crystal must have been nearly or quite one foot in diameter parallel to the brachy-diagonal. It is clear in parts and has a decided greenish tinge. It was supposed to be fluor spar, by the original collectors, and the other pieces of the crystal are undoubtedly lost.

The specific gravity of this fragment is 3·578 at 22° C., and its chemical composition is entirely normal.

Phenacite.

The two crystals of phenacite examined were found together, and are, so far as we can learn, the only ones as yet obtained. They are but fragments, representing in each case

somewhat less than half of the complete crystal. The accompanying figure represents the smaller crystal in about the natural size; the other one measures nearly 7^{cm} in longest diameter, and has the same faces developed in a similar manner. In neither crystal do any faces of the vertical zone appear, thus producing a flat lenticular habitus. The forms appearing have been identified as R, $-\frac{1}{2}$ ($-\frac{1}{2}R$), -1 ($-R$), and $\frac{2}{3}$–2 ($\frac{2}{3}P2$), and although all faces are too rough to admit of exact measurements with the reflection-goniometer, the size of the faces and their simple development renders sufficient accurate results with the hand instrument possible. The angles obtained, as means of several measurements, are—



	Crystal *a*, (fig.)	Crystal *b*.	Authorities.
$R \wedge R$ (terminal)	--------	116° 20′	116° 36′ (D)
$R \wedge R$ (lateral)	--------	63° 00′	63° 24′ (S)
$R \wedge -\frac{1}{2}$ (over $\frac{2}{3}$-2)	148° 30′	148° 50′	148° 18′ (D)
$R \wedge \frac{2}{3}$-2	159° 45′	159° 58′	159° 56′ (D&S)
$R \wedge -1$	74° 30′	74° 40′	74° 42′ 45″ (S)
$-\frac{1}{2} \wedge -\frac{1}{2}$	143–144° 00′	--------	144° 1′ 26″
$-\frac{1}{2} \wedge -1$	--------	163° 43′	163° 32′ 2″
$\frac{2}{3}$-2 $\wedge -\frac{1}{2}$	168° 11′	168° 50′	168° 22′ (S)
$\frac{2}{3}$-2 $\wedge \frac{2}{3}$-2	156° 40′	156° 00′	156° 44′ (D&S)

The figures of the third column are the calculated angles given for phenacite by Dana* or Seligmann†, or else our own calculations based on the theoretical values given by them. The agreement between the angles measured on these crystals and the theoretical ones is sufficiently close to justify the signs given to the faces of the figure. In the development of the different forms, R and $-\frac{1}{2}$ are always prominent, while the faces of $\frac{2}{3}$-2 are variable. One face of $\frac{2}{3}$-2 on crystal *b* is 2·5^{cm} broad, although usually each face of $-\frac{1}{2}$ is broader than both adjoining faces of $\frac{2}{3}$-2; -1 is subordinate, and the faces are quite rough; $\frac{2}{3}$-2 appears with its full complement of faces. The roughness of the faces is in part caused by striæ which on $-\frac{1}{2}$ and $\frac{2}{3}$-2 run parallel to the terminal edge of R replaced by those faces. On R the markings are less distinct. These striæ and partially regular depressions seem like natural etch-figures, and bring out the rhombohedral symmetry of the mineral very plainly.

The crystallographic determination of these crystals as phenacite is confirmed by all the physical characteristics, as far as observed, and by the chemical composition. There is an imperfect cleavage parallel to i-2 ($\infty P2$). Both crystals are clear and colorless, resembling quartz, and the hardness is nearly or quite 8. The specific gravity of the crystal figured, though containing some impurities, is 2·967 at 23° C.

* Dana, System of Mineralogy, Fifth Ed., p. 263.

† G. Seligmann, in "Neues Jahrbuch für Mineralogie," etc. 1880, I, 129.

According to the latest edition of Naumann–Zirkel's "Elemente der Mineralogie" (Leipzig, 1881), phenacite has been described from but four localities—two in the Ural Mountains, one in Lothringen, and one in Mexico. Dana* gives a second locality in Mexico. The crystals described recently by Websky† being from an unknown source, the locality near Pike's Peak seems to be the *sixth* authentic occurrence of this rare mineral, and the first in the United States.

A partly historical description of phenacite and its known forms was given by G. Seligmann in the "Neues Jahrbuch für Mineralogie" etc., 1880, I, 129.

Zircon.

G. A. König has described and analyzed zircon from two occurrences of the Pike's Peak district, in one case the mineral being associated with astrophyllite,‡ and in the other with Amazon-stone.§ In one of the instances we have to describe, the zircon is intergrown with large crystals of flesh-colored microline, in one of the localities above-mentioned, and is thus analogous to the latter occurrence noticed by König. There were many loose crystals in this cavity, but a few were found penetrating or imbedded in the microline. The crystals described by König showed both pyramid and prism, but the prism is entirely lacking on all of our specimens. Some crystals are more than an inch in diameter, and these large ones especially are often mere aggregates of numerous small pyramids grown together with a common crystallographic orientation. The lateral edges of such crystals are often continuous, but the terminations are made up of many small pyramids. Although the pyramid 1 is the only prominent form, one can notice, on looking at the terminations in the right position, a minute reflecting surface on each perfect apex. A closer examination with the loupe shows it to correspond to the basis *O*, but all observed surfaces are too small to admit of certain determination.

Near the Pike's Peak toll-road, about due west from Cheyenne Mountain, a prospect tunnel, in following a vein-like mass of white quartz in granite, has disclosed a number of interesting minerals. The main body of the quartz is pure white in color and contains only traces of galena and chalcopyrite. Within this body, however, is a second smaller vein consisting likewise chiefly of white quartz, but carrying in it a number of other minerals, the most abundant of them being zircon. The

* System of Mineralogy, p. 263.
† Websky, "Neues Jahrbuch für Mineralogie," etc. 1882, I, 207.
‡ G. A. König, Zeitschrift für Krystallographie, I, p. 423.
§ G. A. König, Proc. Acad. Nat. Sci. Philad.

boundary between the two masses of quartz is sharply drawn, but the development of the tunnel is not extensive enough to show clearly the relation of the two bodies.

Throughout the greater part of the vein the zircon is imbedded directly in the quartz and is so abundant that a cubic inch of the latter mineral contains from 25 to 100 crystals and particles of zircon, varying in size from 1^{cm} downward. In parts of the vein, however, are small, irregular spaces filled with a soft, yellow foliate mineral in which are imbedded very perfect crystals of zircon. Fluorite and a white foliate mineral are sometimes associated with the others. The two foliate minerals are as yet undetermined.

This occurrence is worthy of special notice on account of the perfection of the crystals and their transparency. Some of the crystals lying in the quartz are perfectly developed, but usually their growth has been more or less hemmed by the quartz, and many are fissured. The crystals imbedded in the soft, yellow material, however, are often absolutely perfect in form, and beautifully clear. The ruling color is a deep reddish-brown with variations toward pink or a pale honey-yellow. A few crystals are of a deep emerald-green, and spots of the same were noticed in some of the pink crystals.

The common habitus of all crystals is pyramidal, the prisms being always subordinate when they appear. The forms determined with certainty are, 1 (P), 3 ($3P$), O ($0P$), 3·3 ($3P3$), I (∞P) and i-i ($\infty P\infty$). The rare face O is much less frequently developed than any of the others but it was observed distinctly on at least twenty-five crystals. Repeated measurements on different crystals of the angle $O \wedge 1$ give results varying less than 3′ from the calculated value (137° 50′). Between O and 1 is a low pyramid appearing quite constantly with O, which forms an angle of 164° 46′ with 1. This corresponds very nearly to $\frac{1}{2}\frac{4}{3}$ ($\frac{1}{2}\frac{4}{3}P$). The angle between this form and 1 is a curved surface giving an almost continuous reflection, but the angle with O is distinct. The crystals showing O occur in the soft, yellow substance, and the face in question could not have been formed by pressure of the surrounding material. The face O was noticed by König (l. c.) on the zircon occurring with astrophyllite, but his statement has been either overlooked or discredited, as Zirkel, in the recent edition of Naumann's "Elemente der Mineralogie," says that O has not yet been observed, though he cites an analysis by König of the same zircon which showed the basis O. On all but one of our crystals O and the pyramid $\frac{1}{2}\frac{4}{3}$ are developed on one end only, the other showing simply 1, thus giving a hemimorphic appearance to the crystal.

The chemical investigation of this zircon shows it to be

exceedingly pure, and the specific gravity of the transparent crystals is 4·709 at 21° C.

The perfection of the crystals, with their transparency and color, make this occurrence of zircon one of the most beautiful known.

In a paper which we hope may appear in this Journal within a short time, we shall describe several minerals of the cryolite group which occur in connection with a quartz vein in the neighborhood of the zircon locality. Most of these fluorides are identical with those associated with cryolite in Greenland. The body of mineral found is of small extent, but yields a large number of species.

There are also several interesting species more or less closely associated with the zircon, in the study of which we are now engaged. The results we hope to communicate in a future number of this Journal.

Denver, Colorado, August 3, 1882.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *The production of electricity regarded as the equivalence of a chemical process.*—W. Thomson and Joule have shown that in the case of the Daniell cell all the chemical heat of the cell has its equivalence in the electrical current which is produced. J. Thomson has lately shown by careful measurements that the above-mentioned investigators were right as far as the Daniell cell is concerned. W. Thomson, among others, inclines to the belief that chemical heat in the case of all galvanic cells has its equivalence in the electric currents produced. F. Braun in this paper reiterates his objection to the above conclusion as far as it becomes a general one, and shows that in certain galvanic combinations all the chemical heat is not changed into electricity, but only a portion, which he terms useful electro-motive effect. The other portions of the heat are probably employed in internal work among the molecules of the metals and liquids used in the cell. Braun does not believe that polarization can account for the amount of heat that does not have its equivalence in an electrical current. He shows that the theory that in a combination of sulphate and acetate of zinc, copper and cadmium, the whole chemical energy manifested between and at the electrodes of the cells is transformed into the work of the electrical currents produced by these cells, leads to irreconcilable contradictions. He maintains that there are a number of *polarization free* galvanic combinations in which the processes taking place within the cells are fully known, yet which afford more electrical energy than is the equivalent of the heat of these in-

ternal processes. He calls attention to the fact that there are a large number of endothermic reactions—that is, chemical processes in which heat is absorbed—and promises a continuation of his investigation.—*Annalen der Physik und Chemie*, No. 8, 1882, pp. 562–593. J. T.

2. *Absorption of the Electric Light by the Atmosphere.*—Professors AYRTON and PERRY in using their Dispersion Photometer have been struck with the large percentage of absorption of the rays of the electric light by the atmosphere. The green rays on certain days are absorbed by an atmosphere which appears perfectly clear to the eye. The photometer employed by them has become simplified and they now use Rumford's method in preference to other screen methods.—*Phil. Mag.*, July, 1882, pp. 45–51. J. T.

3. *Tension of Mercury Vapor at low temperatures.*—The observations of various observers have differed. Those of Regnault have been generally accepted. Herr E. B. Hagen has made a careful investigation to reconcile the differences of various observers and is led to the conclusion that Regnault's results, which are given in most text-books, are too great. Hagen gives a table of comparison between his results and those of Regnault extending from 0° to 100° (for differences of 10°). At 0° Hagen obtains $0{\cdot}015^{mm}$ and Regnault $0{\cdot}0200^{mm}$. At 100° Hagen gives $0{\cdot}21^{mm}$ while Regnault gives 0·7455.—*Ann. der Physik und Chemie*, No. 8, 1882, pp. 610–618. J. T.

4. *Influence of the quantity of gas dissolved in a liquid upon its surface tension.*—WROBLEWSKI states that in all the liquids studied by him the surface tension in contact with air is a little greater than in contact with carbonic acid. Under pressures of 1 to 30 atmospheres there exists a remarkable relation between the laws of the solubility of carbonic acid in water and the surface tension of that liquid; this relation is given in mathematical form. The phenomena are completely independent of the pressure and depend only on the state of saturation of the surface of the liquid.—*C. R.*, Aug. 7. *Phil. Mag.*, September.

5. *On the state of Carbon in Iron and Steel: a New Hypothesis of the Hardening of Steel;* by R. SYDNEY MARSDEN, D.Sc., F.R.S.E., etc. (Abstract from Proc. Edinb. Roy. Sci., 1881–1882, p. 368.)—This paper first treats of the composition and properties of the different kinds of iron, known as wrought iron, steel and cast iron, and especially of the changes which steel undergoes on being heated to redness and then suddenly cooled by plunging it into water, mercury, or oil, and known as *hardening;* also of the peculiar property known as *tempering*, by which the hardness and brittleness can be removed.

After having passed in review the chief properties of the different kinds of iron, the paper goes on to discuss the different theories that have been proposed to account for these properties.

An objection is raised against the different theories which consider the iron and carbon as chemically united together, on the

grounds that if these hypotheses be true, we are then presented with an anomaly unknown in any other instance, viz., that of two elements uniting together in all proportions up to a certain point, and then suddenly losing this power, and it is very difficult to believe that such can be the case; whilst another difficulty is the fact of the carbon being capable of changing its condition and passing in and out of combination under the action of heat or different methods of cooling, in a manner at once extraordinary and totally different from anything else with which we are acquainted in the whole range of chemistry.

A new hypothesis is then given with regard to the nature of the different kinds of iron.

The carbon is considered to be in a state of solution in the iron, and it is shown (by analogy of what takes place in the case of a solution of carbon in silver) how if the metal be cooled slowly the carbon by preference crystallizes in the graphitic form, which accounts for the carbon in slowly cooled steel and cast iron being chiefly in that condition; but how if the cooling be rapidly effected by plunging the metal in water or running it into a cold mould (as in chill casting) then the carbon is not as it were given the option as to which form of crystallization it will take, but is caused to crystallize in the diamond form, and in this way the hardness of steel and chilled cast iron is accounted for by the presence of an innumerable quantity of excessively minute diamond points disseminated over the whole surface of the hardened metal. It is then shown how (supposing this hypothesis to be correct) such points of difficulty as the following can be explained, namely:

1. What constitutes the difference between steel and white cast iron, and between white and gray cast irons?
2. Why steel requires some time after fusion of the metal to become good steel?
3. How the hardening of steel takes place?
4. Why hardened steel has a less sp. gr. than unhardened steel, and why it is so brittle?
5. How tempering is effected?
6. How the passage of carbon from one condition to another can be accounted for?
7. How re-hardening takes place?
8. How the brittleness of steel is removed by tempering?
9. Why hardened steel instruments when used gradually lose their hardness?
10. Why iron containing from 0·4 to 1·7 per cent. of carbon only presents these properties of hardening and more particularly of tempering that are peculiar to steel?
11. How damascened steel is produced?

Steel is regarded as a normal solution of carbon in iron, and cast iron as a supersaturated solution, and it is shown how the difference between a normal and a supersaturated solution is sufficient to account for differences as great as those between steel and cast iron. Objections to this hypothesis are then discussed, particu-

larly the two strongest, viz., (1) the production of hydrocarbons when hardened steel or white cast iron is dissolved in acids; and (2) the reversed analogy of the copper and tin alloys in favor of the physical theory.

6. *The Limit of the Liquid State of Matter;* by J. B. HANNAY.—The conditions under which an investigation is carried out often predetermine the conclusions to be drawn from the observations made. That this has been the case with the observations made upon the upper confines of the liquid state, there is now ample evidence to show. When Cagniard de Latour, on heating liquids in sealed tubes, noticed the disappearance of the liquid surface, he came to the conclusion that the liquid state had ceased to be possible, and that the substance had passed into the gaseous state. But Latour had no means of varying the volume of his liquid to observe whether or not increase of pressure might again induce liquefaction. This defect was removed by Dr. Andrews, who constructed the well-known apparatus for varying the volume by means of a screw; and it is to the work performed with this apparatus that the above remark is applied. By two modes of observation Dr. Andrews arrived at the conclusion that the liquid and gaseous states of matter were continuous. The experiments being conducted in transparent glass tubes, the appearance of the contained fluid constituted one mode, and the registration of the pressure constituted the other. *Neither of these methods could by the necessities of the case give any aid in determining the state of matter.* Dr. Andrews's method of demonstrating the continuity, by passing from a lower to a higher temperature under a pressure which prevented the formation of vapor, ensured the homogeneity of the fluid under examination, and precluded the existence of a visible liquid surface; and as liquid and gas are equally transparent, no tidings of the state of the fluid under examination could come to him by observations of its appearance. How did Dr. Andrews tell when his tubes contained liquid? By lowering the pressure till a meniscus was seen. *Then the formation of a meniscus is the only test of the liquid state.* Dr. Andrews then obliterated the only ocular test of the fluid's condition by increasing the pressure, and raised the temperature till on again reducing the pressure no meniscus was formed, showing the fluid to be gaseous, and he then declared that no sudden change of state had occurred—that is to say, that it was impossible to say that the fluid was either liquid or gaseous, but that it had probably passed through an intermediate state. Of course a change of state had taken place, and if we only reflect that the change from cohesion to repulsion is caused by the thermal velocity of the molecules, and not by the number of them in a space, the change should depend upon temperature and not upon pressure.

The characteristic property of the liquid state is then the possession of cohesion sufficient to form a surface, or simply surface tension; and could this property be retained in a visible form at

all pressures, the existence of the continuity enunciated by Andrews could be put to a crucial test. By compressing hydrogen over various liquids in which it is insoluble, I was enabled to carry the above proposition into effect, and after several hundreds of experiments, detailed in a paper read before the Royal Society, the conclusion was arrived at that the two states are not more continuous than are the solid and liquid states, but are separated by an isothermal passing through the critical point. In fact by Latour's or Andrews's method, where the liquid was in contact with its own vapor, the critical point is the only place where the direct passage from liquid to gas is visible, but the employment of hydrogen for retaining a free surface enables us to observe the passage at any pressure, and it takes place as suddenly at 200 atmospheres pressure as at the critical pressure. Thus the critical point is the termination of an isothermal line, which is the limit of the liquid state.

As to the other mode employed by Andrews—namely, pressure —continuity of pressure does not prove continuity of state. If it did the continuity of solid and liquid states could easily be proven. In fact, the irregularities observed by Andrews in the vicinity of the critical point rather lend support to the views that a change of state takes place there.

We may state the change thus:—The cohesion of the liquid state is weakened as the thermal motion increases, till the repulsion is in excess of the attraction, and the gaseous state ensues. The evidence I have collected from capillary phenomenon in the paper above referred to proves this to be the case, and shows that pressure has no effect in altering the occurrence of the phenomenon. Thus we are led to the conclusion, that so far from the liquid and gaseous states of matter being continuous and indistinguishable, the liquid limit or "absolute boiling point" *is the only fixed point among the properties of matter.* The freezing point can be altered by pressure, and besides, many bodies like ethyl alcohol may have no freezing point, probably becoming more and more viscous till absolute zero is reached. But all substances may be made to pass into the gaseous state, and even delicate compounds may be rendered gaseous without decomposition when under sufficient pressure. We see then that this important change of state, for which I propose the name Cohesion Limit, and which till lately was supposed to have no existence, is in reality the only fixed point in the relations of the states of matter, being determined by temperature alone.—*Nature*, August, 1882.

7. *Crystallization of silica from fused metals.*—Dr. R. S. Marsden, on an examination of microscopic sections of some Berlin porcelain crucibles which had been used in experiments with fused silver and amorphous carbon at a temperature considerably above the melting-point of the former, found that, while the alumina part of the crucible had undergone little change, the glaze had become a "mass of little crystals of a hexagonal form." Similar prisms were separated from the silver. The crystals quietly

dissolved in hydrofluoric acid, while not acted on by nitric or hydrochloric acid. There were also leaf-like forms, apparently silica, which are not yet fully explained.—*Proc. Roy. Soc. Edinb., Session of* 1880–1881.

II. Geology and Mineralogy.

1. *Geological age of the Taconic System;* by J. D. Dana. Quart. J. Geol. Soc., xxxviii, 397, 1882; read April 5, 1882.—This paper opens with the following paragraphs:

"A paragraph in the "Proceedings of the Geological Society" for the 16th of November last, making part of an abstract of an address by Dr. T. Sterry Hunt sustaining the pre-Cambrian age of the Taconic schists, throws more doubt than is right on the stratigraphical observations that have been made in the region by different geologists. It does not present, as a reason for doubt, any facts from the author's personal investigation convicting these geologists of errors in their statements or conclusions, but simply mentions what the author regards as a possible source of error in any study of folded metamorphic strata, and urges this as a probable source in the present case.

The paragraph says: "The speaker insisted upon the fact that where newer strata are in unconformable contact with older ones, the effect of lateral movements of compression, involving the two series, is generally to cause the newer and more yielding strata to dip towards, and even beneath the edges of the older rock, a result due to folds, often with inversion, sometimes passing into faults. This phenomenon throws much light on the supposed recency of many crystalline schists."

The supposed recency of the Taconic schists, and the observations which have led to the inference that these schists *overlie* certain Lower Silurian strata, are among the points to which the paragraph is meant especially to apply. It implies that in any overlying, apparent or actual, it is *an overlying of newer strata, unconformably.*

The Taconic system, first propounded by Professor E. Emmons about forty years since, in his New York Geological Report, published in 1842, has found a place, right or wrong, in European as well as American geological science. Whether right or wrong is therefore a question of the highest importance. I have hence thought that a brief review of the facts bearing on the two points of *unconformability to the associated rocks* and *geological age*, by one of the workers in the field, would be acceptable to the Geological Society.

The true original Taconic schists are those of the Taconic mountain range, at the base of one portion of which Professor Emmons for many years lived and labored. The range stands along the boundary region between the States of Massachusetts and New York, extends thence northward through western Vermont to its center, and southward across northwestern Connecticut into and through Dutchess County, New York. The

general course of the range is nearly north and south (about N. 10° E., and S. 10° W.), and the length about 150 miles. The schists make the center of the belt. Against nearly all the eastern side of these schists there lies a stratum of crystalline limestone called the *Stockbridge Limestone* by Professor Emmons; and against the greater part of the western, another range of limestone, less perfectly crystalline, the *Sparry Limestone* of Professor Emmons. These three ranges of rocks (the central of schists, the two other of limestone) are all that need be considered: for the question is only this—are these strata conformable, or, as the cited paragraph implies, is the eastern of these limestones a newer rock than the Taconic schist, and unconformable to it?

It is plain, from these statements as to the position of the range, that the opportunities for ascertaining the relation in stratification of the Taconic schists and the adjoining limestones are not confined to a single disturbed area. They occur all along the 150 miles; and observations have been made from the northern end of the range to the southern."

It is next explained that the Taconic rocks here referred to are those of the Taconic range itself; those on which Professor Emmons founded his Taconic system; those which should be called "Taconian" if any are; and that the so-called Taconic slates of Northern Vermont and Canada and of other States or countries are not under consideration.

The paper then shows that all observers who have studied the Taconic range have described the schists and limestones as conformable; that Professors W. B. and H. D. Rogers announced this conclusion in 1841; that Dr. Emmons has published this as a fact in all his writings on the Taconic system; that the conformability and general eastward dip taught by Rogers and Emmons are explained and illustrated in the New York Geological Report of Professor W. W. Mather; (1842) in the Massachusetts Report of Professor Edward Hitchcock; in the Vermont Geological Report, by means of sections and descriptions, by Professor E. Hitchcock and Mr. (now Professor) Charles H. Hitchcock, who make the rocks not older than Lower Silurian; and this result is reiterated by Professor C. H. Hitchcock in a note published in volume xix, of this Journal (1880); that the same conclusion was sustained, after investigations of the Berkshire region, by Sir William Logan, who referred the series of slates or schists and limestones to the Quebec system; that it was still more fully proved by the investigations of Mr. A. Wing, reported at length in this Journal for 1877, who, after new discoveries of fossils, reached the conclusion that the eastern and western limestones and the slates with the accompanying quartzite, represent the whole Lower Silurian.

The paper states further that the writer's study of the rocks, over the country from Central Vermont to Western Connecticut and Dutchess County, New York, was undertaken to ascertain

the fact as to conformability, and resulted in confirming the observations of previous investigators; that it also had in view the age of the rocks, and on this point proved that the western of the two limestones in Dutchess County contained Trenton fossils. To this it adds a mention of the later discoveries of numerous fossils, both Trenton and Calciferous, in the same Dutchess County limestone, by Professor Wm. B. Dwight, and of the earlier detection of Hudson River brachiopods by Mr. Nelson T. Dale, in the adjoining Poughkeepsie slates—part of the Taconic slates of Emmons, the former slates being the direct southwestward continuation of the latter.

On the closing page it is added:

"A word further with regard to the paragraph cited in the early part of this paper from the Proceedings of the Geological Society.

"This paragraph makes the stratigraphical evidence doubtful, because it says, "where newer strata are in unconformable contact with older ones, the effects of lateral movements of compression, involving the two series, is *generally* to cause the newer and more yielding strata to dip towards and even beneath the edges of the older rock."

"The fact here alleged may be questioned. But letting it stand that, under the conditions stated, the newer and more yielding strata are generally made to dip toward the older rock, it has no bearing here; for there is no such general dip along the Taconic range. The limestone of its eastern side, here claimed to be the newer, *does not generally dip toward the older rock*, that is, toward the Taconic schists, which are claimed to be the older. Through nine tenths of the length of the belt, the dip, as all observers have found, and as recognized above, is eastward for both the eastern limestone, the schists, and the western limestone, the westward dip of the eastern limestone occurring, as has been stated, in the region of the higher peaks. Hence the point *insisted* upon by the propounder of the doubt, if true in fact, has no application to the region of the Taconic schists.

2. *Geological Report on Indiana for the year* 1881; JOHN COLLETT, State Geologist. 414 pp. 8vo. Indianapolis, 1882.—In the early pages of this Report, Prof. Collett gives facts respecting the architectural use of the gray Oölitic limestone, Sub-carboniferous in age (St. Louis group), which occurs in the counties of Owen, Monroe, Lawrence, Washington, Harrison and Crawford. Analyses of it were published in the Report for 1878. In an investigation, by Mr. T. H. Johnson, of its strength and elasticity, the modulus of rupture—or the load that would break a beam one inch square, resting on supports one inch apart—was found to be 2,338 lbs. for the sawed material, and 1,477 for the tool-dressed, showing the great weakening that comes from the hammering in tool-dressing. The same for compression was 12,675 and 7,857 lbs.

The following pages treat of the topographical features, geology and economical mineral products of Shelby, Fountain, Delaware

and Bartholomew Counties. The volume is very full in its paleontological portion, which includes a memoir by Prof. JAMES HALL, on the Fauna of the Niagara Group of Central Indiana, covering 130 pages of the volume, with 30 plates; and another by Dr. C. A. WHITE on other fossils of the Indiana rocks, occupying the remaining 55 pages, with 19 plates. Prof. Hall's memoir is chiefly from his paper published in a documentary edition of the New York State Museum Report in 1876, and in 1879 in the Museum edition of the Report, and a later paper in the Transactions of the Albany Institute for 1879. The pages by Dr. White contain descriptions of various Illinois fossils, four of which are new species, and some of the others were never before figured. The last twelve of the plates are made up of figures of corals, engraved many years since by J. W. Van Cleve, and in the text are contained the descriptions of them by the authors on American corals who have identified the species. The new species described by Dr. White are *Gyroceras Elrodi*, from the Niagara group, *Patella Levettei*, from the St. Louis group at Spergen Hill, *Lepidesthes Colletti*, from the Keokuk division of the Subcarboniferous, and *Agaricocrinus Springeri*, probably from the Keokuk or lower Burlington division of the Subcarboniferous. These memoirs on fossils make the Report especially convenient and valuable for the student of Illinois geology. Copies of the original plates of Van Cleve it is now almost impossible to obtain.

3. *Nummulitic deposits in Florida.*—Specimens of a white or yellowish-white friable limestone from the vicinity of the Cheeshowiska River, Hernando County, four miles from the coast, consist chiefly, according to Mr. ANGELO HEILPRIN (Proc. Acad. Sci. Philad., 1882, p. 189), of Nummulites of the genus *Nummulina*. They are of one species, which he names *N. Willcoxi*, from its discoverer Mr. Joseph Willcox. It is remarkable, as stated by the author, that the accompanying fossil mollusks are of species more recent than Eocene, even *living species of fresh-water genera*, viz., *Glandina parallela*, *Paludina Waltonii*, *Ampullaria depressa*. But the genus *Orbitoides*, which had its largest development in the Upper Eocene, is also present, indicating with "little or no doubt" that the rock fragments "derived their faunal character from deposits of a more ancient formation," either Eocene or Oligocene; and the original beds may possibly be now submerged.

4. *Mastodons in New Jersey.*—Prof. LOCKWOOD, in a paper read before the American Association at Montreal, described his discovery and uncovering of mastodon remains in a peat meadow about two miles west of Freehold, New Jersey. The skeleton rested on the hard-pan, beneath the peat, with the right side below and the tusks beneath the neck. It was inferred, from the conditions observed, that the mastodon died on the right bank of the stream which there existed; and, since there lay over the neck many fragments of sticks that had been cut by beavers, it is concluded that the stream was afterward dammed by the beavers so that the pond they made covered the skeleton; subsequently, on

the disappearance of the dam, the pond ultimately was drained, and the area became a peat swamp and afterward a meadow.

The author reported the finding of teeth of a mastodon in two instances at distant intervals, out at sea off Long Branch; and the taking of a tusk and other bones from an ancient buried swamp about fifteen miles south of Long Branch, the swamp having been recently uncovered during a severe storm from the sea. He presented these facts as new evidence of a recent subsidence of the New Jersey coast, and as proof that the mastodon was living in the region after the appearance of the modern beaver. The teeth and tusks were in a bad state of preservation, and crumbled to pieces on reaching the air.

5. *New Fossil Marsupials.*—Prof. E. D. COPE, in the American Naturalist for August, adds three to the two species of kangaroo-like marsupials which he has described from the Eocene of Puerco, New Mexico, and for one of them the new genus, *Polymastodon*, is instituted. The species are *P. Taöensis*, *Catopsalis pollux*, *Ptilodus Troverssartianus* (after Dr. E. L. Trouessart of Angers). He also describes from the same beds *Haploconus entoconus* and *H. Gillianus*.

6. *Fossil Corals of the Niagara and Upper Helderberg Groups*, by JAMES HALL. 60 pp. 8vo. Published in advance of the Annual Report of the State Museum of Natural History. August, 1882.—This paper contains brief descriptions of a large number of new species from the groups above mentioned, fuller descriptions of which, with detailed illustrations, to constitute volumes of the Reports on the Paleontology of the State, have been long ready for publication.

7. *G. Lindström on Silurian Corals from Northern Russia and Siberia* (Svenska v. Akad. Handl., vi, No. 18, January, 1882).—Mr. LINDSTRÖM describes and figures both Lower and Upper Silurian species of coral, and among them new species of the genera *Cyrtophyllum*, *Rhaphidophyllum*, *Zaphrentis*, *Acervularia* and *Palæaræa*.

8. *Supposed subterranean drainage of the interior of Australia.*—In a paper, in the Journal of the Royal Society of N. S. Wales, vol. xv, 1882, entitled "Notes of a Journey on the Darling," by Mr. W. E. ABBOTT, the author refers to the observations of Mr. Russell, which seem to prove that the amount of water received by precipitation over the watershed of the Darling much exceeds that which is carried off by the Darling and by evaporation; and he inclines to the opinion expressed by Mr. Russell, that there is an underground drainage system wholly distinct and different in direction from the surface drainage. The underground water would probably take a course to the southwest; and he suggests that this may have been the course of a more ancient river-system. Some evidence with regard to such subterranean waters is presented from wells which have been sunk in the vicinity of the Darling, and whose flow seems to be independent of variations in that river.

III. Botany and Zoology.

1. G. Briosi. *Sopra un Organo finora non avertito di alcuni Embrioni Vegetali.* Abstract of a Memoir presented in 1881 to the *Accademia dei Lincei*, now published in the Proceedings of the *Stazione Chimico-Agraria Sperimentale* of Rome, by its Director Briosi. Illustrated by eighteen figures on three lithographic plates.—The discovery here announced was made in the first instance upon the germinating seeds of *Eucalyptus globulus.* The caulicle (radicle of systematic writers) is slightly club-shaped, and with broad extremity as it were truncate. Close examination and longitudinal section show an opening at the extremity into a shallow cavity, partly filled by a conical projection from above. This is the incipient root, which develops in the usual way. The hollowed extremity of the caulicle surrounding it grows into an annulus or frill of considerable size, and the whole surface of this promptly developes long "root-hairs," or their equivalents, forming a conspicuous ruff, not unlike that in the portraits of Velasquez and other painters of that period. This ruff of root-hairs is fully developed before these appear on the young root: the whole withers away after the latter has attained a certain development. A great number of species of *Eucalyptus* were examined, some in seed only, others in germination, and all show the same structure. Traces of the same were observed in *Callistemon. Fabricia lævigata* produces the ruff of long root-hairs at the junction of caulicle and root, but without any evident development of the annulus. Species of *Leptospermum* and *Melaleuca* show the annulus more or less. *Myrtus Tarentina* and *M. Romana* accord with *Fabricia.* Extending his observations somewhat into orders allied to the *Myrtaceæ*, Briosi found a beautiful ring of very long hairs at the junction of caulicle and root of germinating *Lythrum Salicaria* and *Heimia salicifolia*, and somewhat the same in three species of *Epilobium;* but found no trace of it in *Godetia* and *Œnothera.*

Briosi naturally takes the function of this collar of hairs on the base of the caulicle to be the same as that of the ordinary root-hairs: it is a provision for the absorption of moisture from the soil, which comes into action at a very early period in germination, before the root and its root-hairs are produced.

An appendix to this interesting paper rehearses some objections made by Professor Caruel to its title, "About an organ of some vegetable embryos hitherto unnoticed,"—first, because he takes the "organ" to be the *coleorhiza* of Richard, and secondly, because Irmisch had, in 1876, mentioned and roughly figured an "annular inflation" at the junction of caulicle and root-radicle in a germinating *Eucalyptus globulus*, and compared it with what is found in many *Cucurbitaceæ*, etc. To which Briosi well rejoins, that this open *calotte* of *Eucalyptus* cannot well be the homologue of the closed *coleorhiza* of Richard, through which the incipient root breaks its way, and which has no

function, the term *coleorhiza* being only an inapt expression of the fact that the root originates within: whereas this is a structure with evident function. Also that Irmisch, as his figure and remarks prove, saw the structure too late to discover its origin and meaning. A. G.

2. *Latent Vitality of Seeds.*—This is the heading of a short article in a recent number of the Gardeners' Chronicle, mentioning "some preliminary experiments to ascertain the effects of different conditions on the latent vitality of seeds," by Van Tieghem and G. Bonnier. Several packets of seeds, supplied by Vilmorin, were, in January, 1880, divided into three equal parts; one portion exposed to the free air but screened from dust; another in closed air, being tightly corked up in a tube; the third placed in pure carbonic acid. At the end of two years the seeds were taken out, weighed and sown. All those which had been exposed to free air had gained in weight; for instance, beans had gained $\frac{1}{50}$ and peas about $\frac{1}{12}$ of their original weight. The seeds confined in closed air had gained a little, peas $\frac{1}{100}$ and beans $\frac{1}{1190}$. The seeds confined in carbonic acid gas hardly at all varied from their original weight. As to comparative germination; of

Peas kept in the free air, 90 per cent germinated.
" " " closed air, 45 " "
" " " carbonic acid, none.
Beans (*Phaseoli*) kept in free air, 98 per cent germinated.
" " closed air, 2 " "
" " carbonic acid, none.

If the full course of experiments gives such results, it will (we should say) be made clear, 1st, that the vegetable embryo in the seed is not strictly speaking latent, but is doing some work, however little, is keeping up a respiration, which is essential to its continued life. 2, That the life of seeds cannot be indefinitely prolonged. *Very old* seeds exposed to the air must be dead by exhaustion, and those deeply buried, by suffocation; and the numerous recorded cases of the germination of ancient seeds are more and more to be distrusted. A. G.

3. *Contributions to American Botany, X.* By SERENO WATSON. From the Proceedings of the American Academy of Arts and Sciences, vol. xvii. pp. 316–382. Issued August 10, 1882, with an Index, pp. 1–5.—This is the tenth of the series of contributions which the author has made since the publication of the Botany of King's Exploration upon the 40th parallel, ten or twelve years ago; which shows unparalleled activity. The leading paper in the present publication is a *List of Plants from Southwestern Texas and Northern Mexico, collected chiefly by Dr. E. Palmer in* 1879–80; Part I, *Polypetalæ*. This collection has been distributed in sets among botanists; and the determination is opportune and important. The Texan portion of the collection is of comparatively small account, having been made at an unpropitious season. That of the adjacent parts of Mexico

(in Coahuila and Nuevo Leon), is most interesting, as few herbaria possess the plants collected in this region by Gregg, Wislicenus and Berlandier. It supplements the earlier collection made by Dr. Palmer in conjunction with Dr. Parry, in the province of San Luis Potosi, which was also distributed, and it contains a good many new plants. Some plants received from Dr. Dugès of Guanajuato, and more from a recent collection of Dr. Schaffner are added. The second paper consists of *Descriptions of New Species of Plants, chiefly of our Western Territories.* Seventy-six species are here characterized, of which 47 are Polypetalæ; two are Gamopetalæ; namely, *Douglasia dentata* of the author's own discovery, in the interior of Washington Territory (very near *D. lævigata*) and *Pedicularis Furbishiæ*, an interesting discovery, "on wet banks of the St. John's River, at Van Buren, Aroostook Co., Maine, and extending along the river for sixty miles. Dedicated to its discoverer Miss Kate Furbish, whose careful study of the flora of her State, and perseverance and success in illustrating it by colored drawings of all the species, richly deserve an appropriate recognition." The remainder are Apetalæ (four more species of *Atriplex* and as many of *Eriogonum*) and Monocotyledones (three of *Allium*, two of *Brodiæa*). One of them is the remarkable *Cypripedium fasciculatum* of Kellogg, now first published, which, in addition to three or four Californian localities, has been detected by Mr. Suksdorf in Washington Territory. The following notice contains the title and contents of another separate issue from the same volume.

4. *Contributions to North American Botany*, by Asa Gray. From Proc. of Am. Academy of Arts and Sciences, vol. xvii. Issued June 26, 1882, pp. 163–230.—It contains: 1. *Studies of Aster and Solidago in the older Herbaria;* to which is added a conspectus of *Solidago* as the species are now understood and received by the writer. 2. *Novitiæ Arizonicæ*, etc., being characters of new species, and critical notes on some old ones, in recent collections, for the most part made in Arizona and adjacent parts of Mexico, California, etc. This publication appears to add 85 new species; some of them were distinguished and named by other botanists. Naturally they run very much to *Compositæ*, three new genera of which are here proposed, viz: *Plummera* (*floribunda*), dedicated to the discoverer, the wife of Mr. Lemmon; *Dugesia* (*Mexicana*), dedicated to Professor Alfred Dugès of Guanajuato, Mexico, a little plant which was formerly named *Lindheimera Mexicana;* and *Hecastocleis Shockleyi*, a very curious Mutisiaceous shrubby Composita, discovered by Mr. W. S. Shockley in Southwestern Nevada. The principal contributors of these *novitiæ* are Mr. and Mrs. Lemmon, Messrs. Pringle, Palmer (Northern Mexican collection), and the Messrs. Parish. From notes and from seeds contributed by the latter is derived the illustration of the embryo and germination of *Bursera microphylla*, at the close of the paper. The plant is remarkable for its biternately divided cotyledons. A. G.

5. *Journal of the Linnean Society; Botany.*—The two most recent numbers, 120 and 121, issued last summer, besides numerous other papers, have the special interest of containing the last writings, and an account of the last investigations, of Charles Darwin, viz: his paper on "*The Action of Carbonate of Ammonia on the Roots of certain Plants*," and "*The Action of Carbonate of Ammonia on Chlorophyll-bodies;* which were read on the 6th and the 16th of March, little more than a month before his death. The two papers are characteristic specimens of the acute and painstaking researches, suggested by seemingly casual observations in former years, the following up of which became the chosen occupation of his later days. As they fill nearly fifty pages of the Journal, we cannot here undertake an analysis of them. One of these numbers likewise contains Francis Darwin's paper *On the connection between Geotropism and Growth*, a convincing reply to some criticisms by Weisner, made by means of new experiments.

In the last number B. Daydon Jackson, the Secretary of the Society, has an article *On the Occurrence of Single Florets on the Rootstock of Catananche lutea* (a Cichoraceous *Composita*), a discovery of M. Battandier in Algeria. A note at the close states that he had just accidentally ascertained that Salisbury knew of these radical solitary flowers, and gives a reference to his Prodromus (1796). Mr. Jackson adverts also to an analogous case, that of the American and much of the Asiatic (but not the European) *Scirpus supinus*, the solitary radical flowers of which were discovered here by Mr. Morong, and announced in this Journal. South African specimens in Kew herbarium also show these peculiar flowers.

Sir Joseph Hooker also characterizes *Dyera, a new Genus of Rubber-producing Plants*, Malayan *Apocynaceæ*, which is appropriately dedicated to the accomplished and efficient Assistant Director of Kew Gardens, T. Thiselton Dyer. H. Marshall Ward, who went to Ceylon for the purpose, here publishes *Researches on the Life-history of Hemileia vastatrix, the Fungus of the Coffee-leaf disease*, an elaborate paper, of 36 pages.

A. G.

6. *Analyses of the ash of Epiphytic Plants*, by A. Dixon. (Journ. Roy. Soc. New South Wales, 1881).—The special object in view in these analyses was to ascertain (1) the amount and kind of ash as compared with plants that grow in ordinary soil, and (2) the relations of the constituents to those afforded by the ash of the tree on which the epiphytes grew. The species examined were ferns of the genus Platycerium and one of an Asplenium.

The *Platycerium grande*, or stag's horn fern, "grows single, and throws out, at intervals of about six months, large barren fronds or plates alternately to the right and left, which cling closely to the fronds which preceded them and to the tree to which it has attached itself at the bottom and sides; whilst the upper part spreads out into a crown, surmounted by antler-like

processes, from which it derives its common name of stag's-horn fern. As the fern grows outward from the tree stem by the addition of plate upon plate, a basket-like space is left behind the crown, or perhaps it should be rather called coronet, to distinguish it from the growing crown of the plant; and this space forms a receptacle for rain, leaves and dust, while the dead plates form a humus-like mass interspersed with small rootlets, which often weighs several hundred weight. In this peaty matter an abundant fauna finds shelter, the specimen which was obtained for examination containing earthworms, centipedes, two species of ant, and several beetles. Some of these probably bring nutriment to the plant from without."

The ash from the live fronds amounted to 8·62 per cent; that from the humus and roots, 3·21 and 2·02 per cent; that from the wood and bark of the tree on which it grew, 1·27 per cent. The analyses of the ash afforded:

	From live fronds.	From humus.	From roots.	From wood and bark of tree.
Potash	33·88	7·05	11·25	14·93
Soda	11·33	2·26	3·61 KCl	8·09
Sodium chloride	1·77	2·26	3·61	trace
Lime	21·99	26·63	42·52	39·91
Magnesia	5·58	2·26	3·61	23·84
Alumina	8·16	12·88	20·55	----
Iron sesquioxide	2·47	1·83	2·90	1·46
Manganese oxide, Mn_3O_4	0·45	----	----	trace
Phosphorus pentoxide	9·18	1·16	1·85	7·94
Sulphur trioxide	1·47	6·33	10·10	trace.
Soluble silica	3·54	----	----	3·89
Silica and undecomp. silicates	----	37·31	----	----
	99·82	99·97	100·00	100·06

The species *Platycerium alcicorne*, similar to the last, but growing not singly but numerous individuals together and forming a common humus mass, and either on projecting rocks or attached to the stems of Casuarinas and other trees, afforded 4·51 per cent of ash from live fronds of a plant grown on a rock, and 4·74 of a plant grown on a Casuarina. The ash contained:

	A. grown on a rock.	B. grown on a Casuarina.	Dead frond of B.	Humus of B.	Casuarina bark & wood.
Potash	20·51	40·48	2·95	7·51	9·59
Soda	17·90	21·68	13·71	----	9·87
Sodium chloride	12·07	10·16 KCl	5·64	9·64	4·01
Lime	13·73	5·03	28·54	39·89	50·57
Magnesia	14·57	4·77	7·07	8·29	11·54
Alumina	10·51	7·28	21·72	13·41	----
Iron sesquioxide	1·26	0·68	4·74	4·63	1·34
Mn_3O_4	1·74	----	----	----	1·85
Phosphorus pentoxide	3·13	4·75	5·38	4·41	8·38
Sulphur trioxide	2·58	3·95	10·25	12·22	trace
Soluble silica	1·73	0·93	----	----	3·24
Sand and silica	----	----	----	----	----
	99·73	99·71	100·00	100·00	100·39

The amount of ash from the withered fronds of B, after separating sand and a trace of copper, was 1·21 per cent; and from

the humus, 1·91 per cent, from the Casuarina wood and bark, 2·03 per cent. In an analysis of the ash (12·35 per cent) of *Asplenium nidus*, the author found no alumina, 28·26 potash, 23·10 potassium chloride, 13·26 sodium chloride, 18·56 lime, 0·87 iron sesquioxide, 5·53 phosphorus pentoxide, 1·11 sulphur trioxide and 2·15 soluble silica =99·56. The ash (1·31 per cent) from the tree on which the Asplenium grew afforded 22·12 potash and 3·93 potassium with no soda and traces only of sodium chloride, with 38·07 lime and 17·07 soluble silica.

The author remarks in conclusion that the epiphytes do not get their inorganic matters from the plants on which they grow; and that the sand often present in the humus indicates that they obtain much in the form of dust.

IV. Astronomy.

1. *Elements of the great Comet of September*, 1882, from observations on Sept. 19·1, 19·9 and 20·9, made at the U. S. Naval Observatory. Communicated by the Superintendent of the U. S. Naval Observatory, Washington, D. C.

T = Sept. 16·9836 Wash. M. T.
π = 57° 23′ 8″
Ω = 346 26 41
i = 142 11 40
ω = 70 56 26
$\log q$ = 7·9395

Agreement of middle place [Obs.—Comp.] $\lambda = -11''$, $\beta = -11''$

Observations.

	h	m	s		h	m	s		°	′	″
Sept. 19·1	2	45	42·7	W. M. T.	11	19	39·8	+	0	7	34
19·9	on meridian.				11	14	18·94	−	0	34	28·5
20·6	on meridian.				11	9	10·97	−	1	19	21·1
23·7	18	19	35	W. M. T.	10	58	12	−	3	9	54

The elements were computed by Messrs. Frisby and Skinner.

Ephemeris computed by Prof. Frisby.

	a h	m	s	δ °	′	log Δ	log r	$\frac{1}{r^2\Delta^2}$
Sept. 10·5	9	56	10	− 0	48·1	0·0330	9·5827	0·221
12·5	10	20	13	− 0	27·8	0·0138	9·4771	0·393
22·5	11	3	20	− 2	14·9	0·0745	9·6144	0·250
26·5	10	50	44	4	40·0	0·0982	9·6794	0·105
30·5	10	41	37	6	48·9	0·1144	9·7847	0·060
Oct. 4·5	10	34	25	8	41·4	0·1275	9·8611	0·040
8·5	10	28	3	10	31·0	0·1383	9·9226	0·028
12·5	10	22	22	12	15·6	0·1467	9·9729	0·022
16·5	10	16	53	13	52·6	0·1532	0·0158	0·017
20·5	10	11	23	15	32·8	0·1584	0·0531	0·014
24·5	10	8	16	− 17	3·2	0·1612	0·0788	0·013

$x = r\,[9{\cdot}99558]\,\sin(171° 43′ 32″ + v)$
$y = r\,[9{\cdot}98796]\,\sin(263° 42′ 42″ + v)$
$z = r\,[9{\cdot}43629]\,\sin(\ 50° 58′\ 0″ + v)$

2. *Anales de la Officina Meteorológica Argentina, por su director* B. A. Gould. Vol. II, 4°, Buenos Aires, 1881.—This volume (for notice of vol. i, see this Journal, xvii, p. 83) contains the results of observations during a period of twenty years, at Bahia Blanca by Senor Caronti, and during seven years at Corrientes

by Senor Fitz-Simon. The observations are discussed in full by Dr. Gould, and the results expressed by trigonometrical formulas and by plates.

3. *Monograph of the Central parts of the Nebula of Orion;* by E. S. HOLDEN. Appendix to the Washington Astron. Observations for 1878. 4°, pp. 230. Government Printing Office, 1882. —This is an elaborate résumé and discussion of all the observations hitherto made on the central parts of this nebula. The accessible published and unpublished drawings are in general reproduced. The author's observations made with the Washington 26-inch telescope from 1874 to 1880 are added, and the monograph very appropriately closes with the photograph taken by Professor Henry Draper, March 14, 1882.

4. *Report of the Superintendent of the U. S. Coast and Geodetic Survey, for the year ending June*, 1878. Washington, Gov. Printing Office, 1881.—Besides the full account of the work on the coasts and in the interior done by the survey during the year, this report has with other subjects in the appendices: Observations on the Transit of Mercury; Adjustment of the primary triangulation between the Kent Island and Atlantic base-lines; Physical Survey of the Delaware river in front of Philadelphia, by Henry Mitchell; Meteorological researches, by Wm. Ferrel; and Discussion of Tides in Penobscot Bay, by Wm. Ferrel.

The triangulation between Kent Island and the Atlantic consisting of sixty-two triangles and stretching over 602 miles, gave for a central line of the chain 29·5 miles long only a difference in length of half an inch, according as the length was computed from the one or from the other base line. The treatment of the triangles is given in full by Mr. Schott and Mr. Doolittle.

The first of Mr. Ferrel's papers is an extended one on cyclones, tornadoes, and waterspouts. An abstract is given on p. 33, vol. xxii.

5. *Report of the Superintendent of the U. S. Coast and Geodetic Survey for the year ending June*, 1879. Washington, 1881.—The Appendices to this report of the late superintendent, Mr. Patterson, include the following among other papers: Comparison of local deflections of the plumb-line, by C. A. Schott; Secular change of magnetic declination in the U. S. and at some foreign stations, by C. A. Schott (fourth edition); Physical Geography of the Gulf of Maine, by Henry Mitchell; The internal constitution of the earth, by B. Peirce; Instruments and methods used for precise leveling, by O. H. Pittmann; Refraction on lines passing near a surface of water in geodetic leveling, by Andrew Braid.

The decided superiority of Clarke's spheroid over Bessel's for the figure of the earth is shown by Mr. Schott.

6. *Resultados del Observatorio Nacional Argentino en Córdoba*, BENJ. A. GOULD, director. Vol. ii. Buenos Aires, 1881.—The first volume of this series was the Uranometria Argentina (see this Journal, xix, p. 376). The present volume contains the zone observations of 1872, being 128 zones with an average of over 100

stars each. Dr. Gould has nearly ready for printing all the observations made at the Observatory up to 1880 inclusive, which reach the enormous number of over 250,000. These will require for proper publication twelve more volumes; and they will constitute one of the most important contributions made to astronomy in this generation.

V. Miscellaneous Scientific Intelligence.

1. *Meeting of the American Association for the Advancement of Science at Montreal.*—The thirty-first meeting of the American Association was held at Montreal, under the presidency of Dr. J. W. Dawson, of McGill College. The meeting opened on Wednesday, August 23, with a General Session in Molson Hall, McGill College. This was called to order by the retiring president, Professor George J. Brush, and the chair was then resigned by him to the president elect, Dr. J. W. Dawson. Introductory remarks were made by Dr. T. Sterry Hunt, chairman of the Local Committee, and a welcome to the Association on behalf of the citizens of Montreal was pronounced by the Hon. J. L. Beaudry, mayor of the city; a reply to these addresses was made by President Dawson. After the transaction of some special business the Session adjourned, and the work of organizing the Sections was proceeded with. In the evening of Wednesday, the address of the retiring president, Professor Brush, was delivered before a large audience in the Queen's Hall, upon the early History of American Mineralogy. Following this address there was a reception of the members of the Association by the Local Committee in the Assembly Room of the same building.

On Thursday the special work of the various Sections was opened by addresses from the several vice-presidents. These officers were as follows: in Section A, Mathematics and Astronomy, William Harkness, (in his absence his address was read by Professor Eastman), W. A. Rogers was later elected to preside over the Section; in Section B, Physics, T. C. Mendenhall; in Section C, Chemistry, H. Carrington Bolton; in Section D, Mechanical Science, W. P. Trowbridge; in Section E, Geology and Geography, E. T. Cox; in Section F, Biology, W. H. Dall; in Section G, Histology and Microscopy, A. H. Tuttle; in Section H, Anthropology, Alex. Winchell, in the absence of Daniel Wilson; in Section I, Economic Science and Statistics, E. B. Elliott. The remainder of Thursday and also Friday, Monday, Tuesday and in case of some of the Sections a portion of Wednesday, August 30, were devoted to the reading of papers, a list of which is given beyond. Thursday evening a reception was given to the members of the Association by the President, Dr. J. W. Dawson, in the new Peter Redpath Museum; and at this time the Museum was formally opened. During a portion of the evening an address was delivered in the Lecture room of the Museum by Rev. H. C. Hovey on Caves and Cave Scenery, illustrated by numerous lantern views. Saturday, August 26, was devoted to

excursions to Quebec and Ottawa, in one or the other of which nearly all the members present took part. Tuesday evening, August 29, a lecture was delivered by Dr. William B. Carpenter, of London, in Queen's Hall, upon the Temperatures of the Deep Sea. Most of the Sections adjourned on Tuesday, and on Wednesday, the 30th, after the election of the officers for the following meeting, as noted beyond, the Association adjourned. On Thursday a concluding excursion to Lake Memphremagog was enjoyed by many of those who remained to the end.

The meeting was with one exception the largest which has ever been held, between 950 and 1,000 names being enrolled. The arrangements made by the Local Committee were in all respects admirable, and the liberal hospitality shown to the members by the citizens of Montreal, as also those of Quebec and Ottawa, was worthy of the highest praise. Nothing was left undone which could contribute in any way to the comfort or entertainment of the visitors. Numerous receptions were given by prominent citizens of Montreal in the afternoons and evenings, and besides the longer excursions mentioned, various shorter excursions to the Lachine Rapids, to the Victoria Bridge and so on, were provided for the unoccupied hours.

The next meeting of the Association, in August, 1883, was appointed to be held at Minneapolis, Minn. The officers elected are as follows:—

President, C. A. Young of Princeton; *Permanent Secretary*, F. W. Putnam (continued); *General Secretary*, J. R. Eastman of Washington; *Assistant General Secretary*, Alfred Springer of Cincinnati; *Treasurer*, Wm. Lilly of Mauch Chunk, Penn.

Vice-Presidents—Section A, W. A. Rogers, Cambridge, Mass.; Section B, H. A. Rowland, Baltimore, Md.; Section C, Edward W. Morley, Cleveland, O.; Section D, DeVolson Wood, Hoboken, N. J.; Section E, C. H. Hitchcock, Hanover, N. H.; Section F, W. J. Beale, Lansing, Mich.; Section G, J. D. Cox, Cincinnati, O.; Section H, O. T. Mason, Washington, D. C.; Section I, F. B. Hough, Lowville, Ky.

Secretaries of the Sections.—Section A, W. W. Johnson, Annapolis; Section B, C. K. Wead, Ann Arbor; Section C, J. W. Langley, Ann Arbor; Section D, A. J. Dubois, New Haven; Section E, Alex. A. Julien, New York; Section F, S. A. Forbes, Normal; Section G, Carl Seiler, Philadelphia; Section H, G. H. Perkin, Burlington; Section I, Joseph Cummings, Evanston.

List of Papers accepted for Reading.

Section A, Mathematics and Astronomy.

A. Hall: Parallax of α Lyræ and 61 Cygni.

C. A. Young: Description of the new 23-inch equatorial recently erected in the Halstead Observatory, at Princeton, N. J.

W. W. Johnson: Inverse elliptic functions and the imaginary period; Circular coördinates, and complex anharmonic ratios.

W. E. Hamilton: A mode of representing any cyclical fact in meteorology.

T. C. Mendenhall: Note on an experimental solution of a problem in the doctrine of chances.

PLINY EARLE CHASE: Conservatism of solar energy.

C. P. HART: On the arithmetic of chords.

WM. A. ROGERS: On the performance of a new form of astronomical level; On a method of reducing different catalogues of stars to a homogeneous system.

P. H. VAN DER WEYDE: Some suggestions on the nature of comets, in connection with recent astronomical and electrical discoveries.

JAMES E. OLIVER: A method of finding the law of linear elasticity in a metal; On the law of distribution for certain plant numbers.

SAMUEL HAUGHTON: New views of Mr. George H. Darwin's theory of the evolution of the Earth Moon system, considered as to its bearings on the question of the duration of geological time.

J. BURKITT WEBB: A method of eliminating the personal equation in transit observations.

CHARLES H. ROCKWELL: Scheme for observing the great Eclipse of May, 1883.

HENRY M. PARKHURST: Bell attachment for telescope circles (with illustration).

Section B, Physics.

S. P. LANGLEY: The color of the Sun.

STEPHEN S. HAIGHT: Danger from lightning increased by telegraph wires.

WM. H. BREWER: On the apparent size of magnified objects.

W. LECONTE STEVENS: On vision by the light of the electric spark; The binocular union of spectral images.

PLINY EARLE CHASE: Atomic phyllotaxy.

GEORGE F. BARKER: On secondary batteries.

DEVOLSON WOOD: The tension of the luminiferous ether.

ALEX. GRAHAM BELL: Upon the electrical experiments to determine the location of the bullet in the body of the late President Garfield; and upon a successful form of inductive balance for the painless detection of metallic masses embedded in the human body; Upon a proposed method of producing artificial respiration by means of a vacuum jacket.

GEORGE ILES: The force of diffusion of the gases forming the atmosphere.

S. W. ROBINSON: Electric induction by stress.

D. P. PENHALLOW: A new soil thermometer.

T. C. MENDENHALL: On the reduction of the electrical resistance of the carbon button by the passage of an electrical current.

H. A. ROWLAND: Concave gratings for use in spectroscopic work.

H. T. EDDY: Radiant heat an exception to the second law of thermodynamics.

A. E. DOLBEAR: On the constitution of magnets; On electrical conduction *vs.* induction; On the telephone as an explorer in an electric field; On vortex ring phenomena; On telegraphing without wires.

W. A. ROGERS: Exhibition of a simple and inexpensive comparator for measuring distances between the limits 1 min. and 1 dm.; Experimental determination of the limits of accuracy in measurements by the sense of feeling; Determination of the relation: Metre des Archives = Imperial yard $+3{\cdot}37015$ inches.

E. S. NICHOLS: On the duration of color impressions upon the retina.

P. H. VAN DER WEYDE: On the diatonic scales obtained in the chromatic scales of equal temperament of 12, 19 and 31 tones in the octave, with exhibition of novel scale indicators and correcting keyboard.

J. R. BARTLETT: Experiments with Siemens' electrical deep-sea sounding apparatus.

CHARLES K. WEAD: On a mean direction integration anemometer.

C. S. HASTINGS: On certain complex flame spectra of sodium.

JAS. D. WARNER: Note on the appearance of a halo on the evening of Aug. 4th, 1882.

RUDOLPH KŒNIG: The influence of harmonics on the timbre of sound.

HENRY CARMICHAEL: An instrument for readily producing low temperatures.

BROWN AYRES: On some phenomena of diffraction due to the shape of the source of light.

EDWIN H. HALL: On the "rotational coefficient" in gold, iron, etc.

Section C, Chemistry.

THOMAS W. TOBIN: On the causes which render flour and organic dust explosive, with suggestions for the prevention of such explosions.

LEONARD P. KENNICUTT: Action of water at 100° C. on the B-phenyltribrompropionic acid.

ALBERT R. LEEDS: Preliminary notice of a new organic base.

H. CARRINGTON BOLTON: Application of organic acids to the examination of minerals: Note on the absorption spectrum of humic acid.

C. F. MABERY and RALPH WILSON: The action of basic hydrate on chlortribrompropionic acids: On certain substituted acrylic and propionic acids.

CHAS. W. DABNEY, Jr.: Notes on effects of different soils upon soluble phosphates; Some derivatives of isopicraminic acid; A benzoyl anhydro acid from B-metamidosalicylic.

C. F. MABERY: On the products of the distillation of wood at low temperatures.

C. C. CALDWELL: Pemberton's method for the volumetric determination of phosphoric acid.

HARVEY W. WILEY and C. A. CROMPTON: Estimation of dextrine in solid commercial starch sugar by loss of rotatory power on solution.

ARTHUR H. ELLIOTT and FRED SANDS: Notes on Bone Oil.

R. B. WARDER: Observations on the contamination of City Wells.

ERNEST H. COOK: Carbon dioxide in the Atmosphere; A simple laboratory appliance.

ARTHUR H. ELLIOTT: On Nitro-saccharose.

Paper from several Agricultural Chemists on the estimation of reverted phosphoric acid.

HARVEY W. WILEY: Direct estimation of dextrose, dextrine and maltose in commercial amylose (sugar starch).

J. B. LAWES and J. H. GILBERT: Determinations of nitrogen in the soils of some of the experimental fields at Rothamsted, and the bearing of the results on the question of the sources of the nitrogen of our crops.

J. SZABÓ: On a new micro-chemical method of determining the feldspars in rocks.

J. KITSEE: Fire-damp indicator.

C. G. WHEELER and F. MENZEL: Transmission of gases through liquids of different densities.

HENRY CARMICHAEL: The solution and late crystallization of gold heated with chlorohydric acid in a sealed tube.

WILLIAM DUDLEY: Remarks on the application of the Iridium knife-edge to analytical balances.

WM. H. ELLIS: Some Tea analyses.

L. W. ANDREWS: On the constitution of Benzole.

Section D, Mechanical Science.

R. H. THURSTON: Newly discovered absolute limit to economic expansion in the Steam Engine.

GÆTANO LANZA: Transverse strength of large Spruce beams.

JOSEPH L'ETOILE: A review of the subjects of atmospheric currents, electricity and gases, with a view to practical aërial navigation by means of balloons.

F. FOSTER BATEMAN: St. Lawrence Bridge and Manufacturing Scheme.

J. BURKITT WEBB: A method of cutting screws of increasing pitch; Indicator attachment for high speeds.

T. R. BAKER: The Permeability of the linings of house walls to air.

W. H. LYNCH: The future of the balloon as a practical means of aërial travel.

SAMUEL MARSDEN: Experiments to determine the strength of cylinders with dome attached, with specimens.

Section E, Geology and Geography.

JAMES HALL: On the relations of Dictyophyton, Phragmodictyum and similar forms with Uphantænia; Note upon the genus Plumulites.

EDWARD ORTON: A Source of the bituminous matter in the Ohio Black Shale (Huron Shale of Newberry); Suggestions as to the History of the Lower Coal-measures of Ohio.

RICHARD OWEN: Contribution to Seismology.

WILLIAM BROSS: The Topography and Geology of the Great Salt Lake valley.

CHARLES WHITTLESEY: Pre-glacial channel of Eagle River, Lake Superior.

J. F. WHITEAVES: Recent Discoveries of Fossil Fishes in the Devonian Rocks of Canada; Note on the occurrence of Siphonotreta Scotica in the Utica formation near Ottawa, Ont.

T. STERRY HUNT: The Eozoic Rocks of Central and Southern Europe; The Serpentines of Italy.

JOHN RAE: Arctic Explorations in North America.

WM. B. DWIGHT: Recent investigations and paleontological discoveries in the Wappinger limestone of Dutchess and neighboring counties, New York.

SAMUEL LOCKWOOD: A Mastodon Americanus in a Beaver dam near Freehold, N. J.

ROBERT B. WARDER: Silicified stumps of South Park, Col.

J. W. DAWSON: Palæozoic Floras of Eastern North America and more especially of Canada.

J. R. BARTLETT: Deep-sea soundings and temperatures in the Gulf Stream off the Atlantic Coast, taken under the direction of the U. S. Coast Survey.

JOS. W. SPENCER: Terraces and Beaches about Lake Ontario; Occurrence of Graptolites in the Niagara Formation of Canada.

GEO. H. COOK: On the Change of relative level of the ocean and uplands on the Eastern coast of North America.

M. L. BRITTON: On a Post-Tertiary Deposit containing impressions of leaves in Cumberland County, N. J.

W. O. CROSBY: On the classification and origin of Joint structure.

G. H. PERKINS: On the Winooski Marble of Vermont, with exhibition of specimens.

ALEXIS A. JULIEN: The Comparative stratigraphy of the crystalline rocks of North Carolina and Canada; The Genesis of the crystalline iron ores of North Carolina and Northern Michigan; The Dunyte beds of North Carolina; The Felsyte-tufa of Colorado.

H. F. WALLING: The origin of joint cracks.

H. CARVILL LEWIS: The great terminal moraine across Pennsylvania.

E. W. CLAYPOLE: Note on the exterior markings of bark of Lepidodendron Chemungense; On Amphicœlia Cedarvillensis from the Niagara group of Cedarville, Ohio; Note on the Fauna of the Catskill Red Sandstone.

CHAS. H. GRAHAM: A Rocking Stone in New York city.

W. HAMILTON MERRITT: Occurrence of Magnetic ore deposits in Victoria County, Ontario.

HENRY S. WILLIAMS: The Undulations of the rock-masses across Central New York State.

D. W. KOWALEVSKY: Freshwater lignitic series of the beds in the Cretaceous formation of France.

JOHN C. SMOCK: On the surface limit of the thickness of the Continental glacier in New Jersey and adjacent States, with notes on glacial phenomena in the Catskills.

C. H. HITCHCOCK: The Glacial flood of the Connecticut River Valley.

J. S. NEWBERRY: Some mooted points in American Geology; Genesis of North American Flora.

J. BEAUFORT HURLBERT: Currents of air and ocean in connection with climate; Regions of summer rains and summer droughts.

HORACE C. HOVEY: Subterranean Map-making, with new maps of Mammoth and Luray Caves.

RICHARD OWEN: Law of fracture or fissuring, applied to Inorganic and Organic matter.

F. COPE WHITEHOUSE: The Caves of Staffa and their relation to the ancient civilization of Iona.

R. B. HARE: On the association of crystals of Quartz and Calcite in parallel position.

Section F, Biology.

THOMAS MEEHAN: The Fertilization of Yucca.

WILLIAM OSLER: Demonstration of a series of Brains prepared by Giacomin's method.

ROBT. E. C. STEARNS: Description of a new species of Alcyonoid Polyp.

W. H. EDWARDS: On the Polymorphism of Lycæna pseudargiolus.

E. W. CLAYPOLE: Note on the Sterility of the Canada Thistle at Yellow Springs, Ohio; Insects *versus* Flowers in the matter of fertilization; Note on the occurrence of traces of a Northern Flora in Southwestern Ohio.

WM. SAUNDERS: On the Mouth of the larva of Chrysopa.

MRS. A. B. BLACKWELL: Cross heredity from sex to sex.

ASA GRAY: Some remarks on the Flora of North America.

HENRY F. OSBORN: Achænodon from the Bridger Eocene beds.

HENRY O. MARCY: The Placental development in Mammals.

W. S. BEAL: The motion of roots and radicles of Indian Corn and Beans.

C. V. RILEY: Observations on the fertilization of Yucca, and on structural and anatomical peculiarities in Pronuba and Prodoxus; The Hibernation of Aletia xylina in the U. S., a settled fact; Emulsions of petroleum and their value as insecticides.

W. K. BROOKS: A sketch of the history of our knowledge of the budding of Salpa; Fritz Miller and the Nauplius of Decapods.

T. WESLEY MILLS: Examination of some controverted points of the physiology of voice.

G. MACLOSKIE: Achenial hairs and fibers of Compositæ; Observations on the Elm-leaf Beetle (Galeruca xanthomelana).

WM. H. SEAMAN: Blastesis tridens; a pear-tree fungus.

J. F. WHITEAVES: On a recent species of Heteropora from the Strait of Juan de Fuca.

W. A. BUCKHOUT: On the Gall Mites.

J. A. LINTNER: A new Sexual character in the pupæ of some Lepidoptera; On an Egg parasite of the currant saw-fly, Nematus ventricosus.

CLARENCE J. BLAKE: On the position of the Gamopetalæ; Progressive growth of Dermoid coat of the Membrana tympani.

FRANK BAKER: The Morphology of arteries.

ALBERT S. BICKMORE: The Jessup collection to illustrate American Forestry in the Museum of Natural History, Central Park, New York.

LESTER F. WARD: The Organic Compounds in their relations to life; Classification of organisms.

BURT G. WILDER: On the habits of Cryptobranchus.

C. E. BESSEY: Some observations on the action of frost upon leaf-cells.

EDWARD D. COPE: The Fauna of the Puerco Eocene; The primary divisions of the Ungulata.

WYLLIS A. SILLIMAN: Remarks on the Turbellaria.

JOSEPH F. JAMES: Monograph of the Clematidæ of the United States.

SERENO WATSON: Notes on the Flora of the Rocky Mountains.

Section G, Histology and Microscopy.

WM. B. CARPENTER: On angular aperture in relation to biological investigation.

W. OSLER: Demonstration of the Bacillus of Tuberculosis; The third Corpuscular element in the Blood; The development of Blood Corpuscles in the bone-marrow; Note on the Microcytes of the blood, and their probable origin.

LOUIS ELSBERG: Plant-"cells" and living matter.

HENRY O. MARCY: Histology of uterine fibroid tumors. Illustrated by micro-photographs.

T. J. BURRILL: Some vegetable poisons.

W. A. ROGERS: A study of the problem of fine rulings with reference to the limit of naked eye visibility and microscopic resolution; On a new form of dry mounting.

THOMAS TAYLOR: The House Fly considered in connection with the distribution of infectious and contagious poisons: A new economic freezing Microtome for section-cutting, with new mechanical devices.

A. H. TUTTLE: On the epidermis of Marsipobranchs.

D. P. PENHALLOW: Notes on some of the peculiarities incident to the diseases of fruits.

ROMEYN HITCHCOCK: Notes on the present status of sanitary inspection, with special reference to the examination of water and air.

C. E. HANAMAN: A filtering wash-bottle adapted to the use of the Histologist.

J. H. PILLSBURY: Development of Cilia in the planula of Clara leptostyla.

Section H, Anthropology.

OTIS T. MASON: A Scheme of Anthropology.

CHARLES WHITTLESEY: The Cross and the Crucifix.

G. H. PERKINS: Notice of a collection of Sioux weapons and articles of dress; Recent Archæological discoveries in Vermont.

J. MCNAB CURRIER: Stone implements from Bomoseen and Castleton Valleys.

CHARLES RAU: A Stone Grave in Illinois.

ALBERT S. GATSCHET: Chief deities in American religions.

MRS. ERMINNIE A. SMITH: Beliefs and superstitions of the Iroquois Indians; A few deductions from a dictionary of the Tuscarora dialect.

J. OWEN DORSEY: On the comparative phonology of four Siouan languages; The kinship system and marriage laws of the Dhegiha.

P. R. HOY: Who made the native copper implements? Who built the mounds?

F. W. PUTNAM: On Copper implements and ornaments from North America; Discovery of the remains of a log-building belonging to the stone-grave period in Tennessee; Account of three mounds explored in Ohio and Tennessee; The contents of eighty-four stone graves at Brentwood, Tenn.

HORATIO HALE: Indian migrations, as evidenced by language.

J. W. PHENE: On some hitherto unnoted affinities between ancient customs in America and on the other continents.

R. G. HALIBURTON: Atlas and the Atlantes.

H. N. RUST: A "find" of chipped stone articles on the Pacific coast and exhibition of the specimens; Remarks upon the Davenport tablet.

WILLS DEHASS: Monumental and art remains in the Lake regions of Ohio, Pennsylvania and New York; Mountain antiquities; Geological testimony to the antiquity of man in America; Archæological exploration, progress of discovery.

A. E. DOUGLAS: A find of ceremonial weapons in Florida.

MISS ALICE C. FLETCHER: Home life among some of the Indian tribes; Religious ceremonials of some of the Dakotan family of Indians.

MISS VIRGINIA K. BOWERS: The bleaching of the Aryans.

WM. H. HINGSTON: Influence of climate of Canada on Europeans.

Section I, Economic Science and Statistics.

CHAS. W. SMILEY: Exhibition of some statistics of College men; Notes upon some methods and results of collecting statistical matter by mail.

E. B. ELLIOTT: On international standard time; on certain Government securities; Suggestions on electrical units.

FRANKLIN B. HOUGH: Upon the investment of labor and capital in forest culture as compared with other productive industries; Experimental plantation of Eucalyptus near Rome.

J. OWEN DORSEY: On methods of obtaining registration of vital and other statistics of the Omahas and cognate tribes of Indians.

J. R. DODGE: Statistics in agriculture.

JAMES HYATT: References to some of the economic and scientific principles in tree-growth and tree-destruction.

WINSLOW UPTON: Standard time for North America.

Three of the papers are published in the preceding pages, and others will appear in the following number of this Journal.

2. *British Association; fifty-first meeting, at Southampton.*—The fifty-first meeting of the British Association opened on the 23d of August. The address of the president of the year, C. W. SIEMENS, related especially to recent practical applications of science, to which some of the profoundest workers in pure science have contributed—scientific progress having "rendered theory and practice so interdependent that an intimate union of them is a matter of absolute necessity for our future progress." Mr. Siemens first speaks of the importance of adopting generally in his country the metric system, which is now legalized there and used in science; and passing from this subject of "accurate measures of length, weight and time," discusses the subject of unit measures in electricity. He proposed four new units: (1) a unit of power to be called a "Watt" = the rate of doing work when a current of one ampère passes through a resistance of one ohm, or, $\frac{1}{746}$ of a horse-power, thus eliminating a factor which comes into calculations; (2) a unit of magnetic pole, to be called a "Weber;" (3) a unit of magnetic field, to be called a "Gauss;" (4) a unit of heat, to be called a "Joule" = the amount of work done, or its equivalent, the quantity of heat generated, by the ampère flowing through an ohm for one second. The *watt* and *joule* were unanimously approved by the Association at one of the sessions of the Physical section. Another topic of the presidential address was the electric current as a means of transmitting power, which was discussed in its application to telegraphy, to the telephone, "that marvel of the present day," in connection with which "the names of Reiss, Graham Bell, Edison and Hughes, will ever be remembered;" and to the transformation of electricity into mechanical energy and its application for the transmission of power; stating, on this last point, that "the small space occupied by the electro-motor, its high working speed, and the absence of waste products, render it specially available for the general distribution of power to cranes and light machinery of every description. A loss of effect of 50 per cent does not stand in the way of such applications, for it must be remembered that a powerful central engine of best construction produces motive power with a consumption of two pounds of coal per horse-power per hour, whereas small engines distributed over a district would consume not less than five; we thus see that there is an advantage in favor of electric transmission as regards fuel, independently of the saving of labor and other collateral benefits."

He remarked further that "the electric railway posseses great advantages over horse- or steam-power for towns, in tunnels, and in all cases where natural sources of energy, such as waterfalls, are available; but it would not be reasonable to suppose that it will in its present condition compete with steam propulsion upon ordinary railways. The transmission of power by means of electric conductors possesses the further advantage over other means of transmission that, provided the resistance of the rails be not very great, the power communicated to the locomotive reaches its

maximum when the motion is at its minimum—that is, in commencing to work, or when encountering an exceptional resistance —whereas the utmost economy is produced in the normal condition of working when the velocity of the power-absorbing nearly equals that of the current-producing machine."

He next touched on the deposition of metals by the electric currents; heating and lighting by electricity; the relative values of gas and steam as motive powers, under which the gas or caloric engine is stated "to combine the condition most favorable to the attainment of maximum results," and that "it may reasonably be supposed that the difficulties still in the way of their application on a large scale will gradually be removed;" the ways of improving steam ships and their equipment; the deep-sea sounding machines of Sir William Thomson; and some of the recent engineering projects and accomplishments.

Mr. Siemens closed with remarks on the progress now making toward a clearer conception of the condition of matter when particles are left some liberty to obey individually the forces brought to bear on them, as in vacuum and in interstellar space. He quotes the result of the last eclipse expedition as follows: "Different temperature levels have been discovered in the solar atmosphere; the constitution of the corona has now the possibility of being determined, and it is proved to shine with its own light. A suspicion has been aroused once more as to the existence of a lunar atmosphere, and the position of an important line has been discovered. Hydro-carbons do not exist close to the sun, but may in space between us and it;" and then alludes to a speculation of his own, in a paper read March last before the Royal Society, concerning the conservation of solar energy, which was based on the three following postulates:

"1. That aqueous vapor and carbon compounds are present in stellar or interplanetary space.

2. That these gaseous compounds are capable of being dissociated by radiant solar energy while in a state of extreme attenuation.

3. That the effect of solar rotation is to draw in dissociated vapors upon the polar surfaces, and to eject them after combustion has taken place back into space equatorially.

"It is therefore a matter of peculiar gratification to me that the results of observation here recorded give considerable support to that speculation. The luminous equatorial extensions of the sun which the American observations revealed in such a striking manner (with which I was not acquainted when writing my paper) were absent in Egypt; but the outflowing equatorial streams I suppose to exist could only be rendered visible by reflected sunlight, when mixed with dust produced by exceptional solar disturbances or by electric discharge; and the occasional appearance of such luminous extensions would serve only to disprove the hypothesis entertained by some, that they are divided planetary matter, in which case their appearance should be per-

manent. Prof. Langley, of Pittsburg, has shown, by means of his bolometer, that the solar actinic rays are absorbed chiefly in the solar instead of in the terrestrial atmosphere, and Capt. Abney has found, by his new photometric method, that absorption due to hydrocarbons takes place somewhere between the solar and terrestrial atmosphere; in order to test this interesting result still further, he has lately taken his apparatus to the top of the Riffel with a view of diminishing the amount of terrestrial atmospheric air between it and the sun, and intends to bring a paper on this subject before Section A. Stellar space filled with such matter as hydrocarbon and aqueous vapor would establish a material continuity between the sun and his planets, and between the innumerable solar systems of which the universe is composed."

The address of Lord Rayleigh, before the Mathematical and Physical section, related to the recent progress in physics and the methods necessary for the best progress. With regard to the two schools of physicists, the mathematical and experimental, he well observes: "The tendency of the purely experimental school is to rely almost exclusively upon direct evidence, even when it is obviously imperfect, and to disregard arguments which they stigmatise as theoretical. The tendency of the mathematician is to overrate the solidity of his theoretical structures, and to forget the narrowness of the experimental foundation upon which many of them rest."

Professor G. D. Liveing, President of the Chemical section, observed that the most important progress recently made in chemistry had been in the "attempt to place the dynamics of chemistry on a satisfactory basis, to render an account of the various phenomena of chemical action on the same mechanical principles as are acknowledged to be true in other branches of physics." In his introduction of the subject he said:

"But how far can we say that mechanical principles are actually recognized as the true basis of rational chemistry? So far as I know no chemist denies that it is so, and yet how little do our text-books, even the most recent and the most highly reputed, show the predominance of this idea! How very small a portion of such books is taken up with it; how much seems utterly to ignore it, or to be couched in language which is antagonistic to it! We still find chemical combinations described as if they were statical phenomena, and expressions used which imply that two perfectly elastic bodies can by their mutual action alone bring each other into fixed relative positions. We still find change of valency described as a suppression of "bonds of affinity," as if a suppression of forces were the usual course of nature, or as if it were possible that the same two forces, acting at the same place and in the same direction, should at one time neutralize one another, and at another time not neutralize one another. We still find saturated compounds spoken of, as if the stability of a compound were independent of circumstances, and chemical

combination no function of temperature and pressure. Beginners are sometimes helped by the invention of intermediate reactions in explanation of final results, without any reference to the dynamical conditions of the problem, without any consideration whether the fancied intermediate reactions imply a winding up or running down of energy. In fact our long familiar chemical equations represent only the conservation of matter, and to keep always in mind the mechanical conditions of a reaction is as difficult to some of us as it is to think in a foreign language. Moreover we still find in many of our text-books the old statical notion of chemical combination stereotyped in pictures of molecules. I do not, of course, mean to accuse the distinguished inventors of graphic formulæ of meaning to depict molecules, for I believe they would agree with me in thinking that these diagrams do not any more nearly represent actual molecules than they represent the solar system; but unfortunately we cannot prevent beginners from regarding them as pictures, and moulding their ideas upon them."

Professor Liveing observes that "the vortex theory, whether we think it probable or not, at least gives us a standing ground for the assertion that the supposed impenetrability of matter, and the curious compound of nucleus and atmosphere which has been invented to account for elasticity, are not necessary assumptions. The kinetic theory of gases has analyzed for us the different motions of the molecules in a mass of matter, and has facilitated the conception of the part which heat plays in chemical action. Hence we have had of late several attempts to reduce to a form susceptible of mathematical calculation the problems of chemistry. Most of these attempts have proceeded on the well-known mechanical principle that the change of *vis viva* of a system in passing from an intial to a final configuration is independent of the intermediate stages through which it may have passed so long as the external conditions are unaltered; and on the principle of the dissipation of energy, that is to say, on the condition that the state of the system, if it be a stable one, must be such that the energy run down in reaching it is a maximum. These principles have been applied successfully to the solution of some particular cases of the equilibrium between a mixture of chemicals by Willard Gibbs, Berthelot, and others. By the first-mentioned principle, all consideration of the intermediate stages by which the final result is reached is avoided. Quite recently Lemoine has attacked the same problem on another principle. His principle is that of an equilibrium of antagonistic reactions in a mixture of materials, a mobile equilibrium such as we are now familiar with, dependent on compensating effects; but he does not seem able to solve the problem in any great number of cases. In fact, the difficulty does not now lie so much in expressing mathematically the conditions of the problem as in the defect of knowledge which depends upon experiment. And it is just in this that I think the outlook most hopeful. In some cases the

patient work of weighing and measuring and comparing, which is necessary to make our theoretic speculations of any substantial value, has been already done for us. The publication, three years since, of Berthelot's essay on chemical mechanics has given us in a collected form a large quantity of data of the first importance; and now I am glad to say that the long labors of another worker in the same field, Thomsen of Copenhagen, are in course of publication in a handy form. I think these two investigators have done more than any one else of late years toward making it possible to give to chemistry the rank of an exact science. But besides the data which they have supplied to us, there are others which are still wanting. For instance, almost every equation of chemical equilibrium involves an expression depending on the specific heats of the materials. At present we do not know enough of the law of specific heats to be able to give in most cases a probable value to those expressions; but these and other data of the kind do not seem out of our reach, and we may hope that the same ingenuity and patience which has gained for us so much firm ground in thermal chemistry will extend it to the uncertain spots where we have yet no solid foundation.

Further, the laws of dissociation so ably investigated by Deville have taught us that the force called chemical affinity, by which we suppose the atoms of unlike matters are held together in a compound molecule, follows precisely the same laws as the force of cohesion, by which particles of a similar kind are united in molecules."

Dr. ARTHUR GAMGEE, president of the section of Biology, ably discussed "the growth of our knowledge of the function of secretion."

The president of the Geological section, ROBERT ETHERIDGE, took for his subject one of local as well as general interest, a review of what had been hitherto done in the study of the Tertiary rocks of the Hampshire basin.

Sir RICHARD TEMPLE, President of the Geographical section, discoursed instructively on the Central Plateau of Asia—its mountains, river-sources, plateaus, lacustrine systems, and the importance of the further investigation of the great region to the sciences of terrestrial physics, geology and meteorology, as well as to that of general history and sociology.

In the section of Biology, the vice-president, in the department of Anthropology, Professor DAWKINS, spoke on "the present phase of the Antiquity of Man." Professor Dawkins remarked upon the great improbability of the discovery of remains of man in the Eocene or Miocene from the fact that the known placental mammals of the first of these periods are all of extinct genera, and from the second of extinct species; for the most specialized of all animals cannot be looked for until the higher mammalia by which he is now surrounded were alive. He adds, "nor in the

succeeding Pliocene can we expect to find man upon the earth, because of the very few living species of placental mammals then alive. The evidence brought forward by Professor Capellini, in favor of Pliocene man in Italy, seems both to me and to Dr. Evans unsatisfactory, and that advanced by Professor Whitney in support of the existence of Pliocene man in North America, cannot in my opinion be maintained. It is not until we arrive at the succeeding stage, or Pleistocene, when living species of Mammalia begin to abound, that we meet with undisputable traces of the presence of man on the earth."

He next gives a general review of the mammalian life of the Pleistocene or Quaternary era, with reference to the associates of the earliest remains of man, called by him "River-drift Man," speaks of English, European and American discoveries, and gives the following as his general conclusions:

"It remains now for us to sum up the results of this inquiry, in which we have been led very far afield. The identity of the implements of the River-drift hunter proves that he was in the same rude state of civilization, if it can be called civilization, in the Old and New Worlds, when the hands of the geological clock pointed to the same hour. It is not a little strange that his mode of life should have been the same in the forests to the north and south of the Mediterranean, in Palestine, in the tropical forests of India, and on the western shores of the Atlantic. The hunter of the reindeer in the valley of the Delaware was to all intents and purposes the same sort of savage as the hunter of the reindeer on the banks of the Wiley or of the Solent. It does not, however, follow that this identity of implements implies that the same race of men were spread over this vast tract. It points rather to a primeval condition of savagery from which mankind has emerged in the long ages which separate it from our own time.

It may further be inferred, from his wide-spread range, that the River-drift man (assuming that mankind sprang from one center) must have inhabited the earth for a long time, and that his dispersal took place before the glacial submergence and the lowering of the temperature in Northern Europe, Asia and America. It is not reasonable to suppose that the Straits of Behring would have offered a free passage, either to the River-drift man from Asia to America, or to American animals from America to Europe, or *vice versa*, while there was a vast barrier of ice or of sea, or of both, in the high northern latitudes.

I therefore feel inclined to view the River-drift hunter as having invaded Europe in pre-glacial times along with other living species which then appeared. The evidence, as I have already pointed out, is conclusive that he was also glacial and post-glacial.

In all probability the birthplace of man was in a warm if not a tropical region of Asia, in 'a garden of Eden,' and from this the River-drift man found his way into those regions where his implements occur. In India he was a member of a tropical fauna, and his distribution in Europe and along the shores of the Medi-

terranean prove him to have belonged either to the temperate or the southern fauna in those regions.

It will naturally be asked, to what race can the River-drift man be referred? The question, in my opinion, cannot be answered in the present stage of the inquiry, because the few fragments of human bones discovered along with the implements are too imperfect to afford any clue. Nor can we measure the interval in terms of years which separate the River-drift man from the present day, either by assuming that the glacial period was due to astronomical causes, and then proceeding to calculate the time necessary for them to produce their result, or by an appeal to the erosion of valleys or the retrocession of waterfalls. The interval must, however, have been very great to allow of the changes in geography and climate, and the distribution of animals which has taken place—the succession of races, and the development of civilization before history began. Standing before the rock-hewn tombs of the kings at Luxor, we may realize the impossibility of fixing the time when the River-drift hunter lived on the site of ancient Thebes, or of measuring the lapse of time between his days and the splendor of the civilization of Egypt.

In this inquiry, which is all too long, I fear, for my audience, and all too short, I know, for my subject, I have purposely omitted all reference to the successor of the River-drift man in Europe—the Cave man, who was in a higher stage of the hunter civilization."

The first of the evening lectures was that of Sir WILLIAM THOMSON, *on the Tides*. The Athenæum of September 2d, reports: "It was delivered with but few notes and without much regard to exact logical consecution of topics; but the intense energy of the lecturer and the startling points he made sustained the attention of the audience. The subject is one which, as chairman of the Tidal Committee of the Association, he has worked at for many years, and one result of his labors has been the publication of very complete tide tables for the principal Indian ports. Another result, of great importance to the geologist, is a determination of the amount by which the solid earth yields to the same distorting forces which produce tides in the sea. If it were of India rubber, or, what amounts to much the same thing, if it had a crust only twenty or thirty miles thick, with fluid within, its yielding would be so great as practically to prevent any tidal currents from being formed in the water, for the formation of these depends upon the water yielding more than the land. Sir William's calculations show that the actual amount of yielding on the part of the land is less than it would be in a solid globe of glass of the same size. The latest forms of his tide guage and tide-predicting machine were exhibited, and his harmonic analyzer was explained by the aid of a diagram."

The report of the committee appointed for the purpose of obtaining photographs of the typical races of the British Isles, gives the following definitions of the main types:

"*The First or Dolichocephalic Dark Type, A.*—The definition of the short, narrow-headed race shown by Dr. Thurnam and Professor B. Dawkins to have preceded the so-called Celts, and termed by them Iberian (=the Silurian of Professor Rolleston), is at present incomplete. The forehead, however, appears to have been fairly vertical, the brows prominent, the nasal bones long and straight, the lower jaw weak (Rolleston), and the hair and eyes dark. Statistics of the color of the hair and eyes, collected by Dr. Beddoe, show that the race exerted a much wider influence on the population than is usually supposed.

The Second or Brachicephalic Fair Type, B.—The principal characteristics of this race consist in the prominence of brow and supra-nasal ridges; a slightly receding forehead; sharply projecting nasal bones, causing a high-bridged or arched nose, without undulation; a long, oval face; high cheek-bones; and a prominent fine chin. From Mr. Park Harrison's observations the lips of this type appear to be thin, and the ear pear-shaped, with no proper lobe, the fossa being continuous.

These features are found associated with light hair and eyes, and a stature above the average. This type includes Belgic, Cymric, and Danish varieties, which, further observation, the Committee believe, will by-and-bye enable them to differentiate; as also the Anglian, Jutish and Frisian types. They have selected several portraits, which present common characteristics.

The definition of Type B agrees in all the main points with descriptions given some years ago by Dr. Beddoe, Mr. David Mackintosh, and Mr. Hector Maclean, as well as with Dr. Rolleston's deductions in the appendix to 'British Barrows.'

The Third or Sub-Dolichocephalic Fair Type, C.—The Committee believe that the following is a correct definition of true Saxon features. Brows smooth; forehead rounded and vertical; nasal bones short and straight; nose not arched, ending in more or less of a bulb; face elliptical, rounded; cheek-bones broad; chin rounded; lower part of face wide; eyes prominent, in color blue or bluish grey; lips moulded; ears flat, with formed lobes; face and frame well covered. Height about the average.

The definition accords with Schadow's pure German (Teutonic) type, and with the Saxon type of Beddoe and Mackintosh."

The preceding notes on the meeting of the British Association have been taken almost wholly from Nature, whose numbers, commencing with No. 669, for August 24, contain full reports of the presidential addresses, and copious abstracts of the reports, papers read, and other proceedings.

The British Association, after much discussion, decided, by a vote of fifty-three to thirty-nine, to hold its meeting in 1884 at Montreal. The Athenæum of September 2d says:

"Great inducements were offered in the shape of facilities for traveling; and the rare chance thus afforded of seeing America was doubtless a powerful attraction, especially to the younger portion of the members. At the worst, no very great harm can

come of it. The regular work of the Association is not so vitally essential that a year's interruption for the sake of a holiday tour will produce any very grave inconvenience."—It can be safely promised that the scientific men of America will do what they can toward making the harm very small, and the profit of the occasion great in all respects.

3. *Report of the New York State Survey (Trigonometrical) for the year* 1880, JAMES T. GARDINER, Director. 80 pp. 8vo, with five maps. Albany, 1881.—This report announces the completion of a line of triangulation across the State of New York, from the Massachusetts line in the town of Canaan to the western boundary near Lake Erie. The width of the State between these points is found to be 326·46 miles, instead of 328·68, the result of former measurements. The exact location also of twenty-three cities and villages along the line has been determined. The position of the southern boundary of the State along by Pennsylvania and New Jersey is promised in the report as another practical result of the triangulation soon to be realized.

4. *On the Cause of the Infection of the Waters at Lille;* by M. ALF. GIARD.—The reddish color, bad taste, and unpleasant odor presented at times by the waters of the Emmerin springs which supply the town of Lille have long been noticed by the population of that town; but in the spring of this year the infection assumed alarming proportions. On the 22d of April the water was absolutely unusable; and from that time every somewhat copious rainfall was followed by a longer or shorter period of more or less intense infection. During these periods the water carries on its surface a ferruginous red scum which can easily be collected by stretching cloths across the stream. Ferruginous deposits also form in the reservoirs and in certain parts of the distributing channels. These on certain days were so abundant that the horses refused to drink the water which was offered to them. A microscopic examination showed that the cause of the infection was a Schizomycete, *Crenothrix Kühniana* Rabenh., the filaments of which become charged, in contact with the water exposed to the air, with a precipitate of sesquioxide of iron, then putrefy, and communicate a most disagreeable flavor to the water.

This *Crenothrix* has been noticed in several localities, especially Halle, Breslau and Berlin, and has been carefully studied by Professors F. Cohn, O. Brefeld and W. Zopf. To the observations of those eminent botanists we have only to add that the microgonidia, formed in the swollen extremities of the tubes of *Crenothrix* by transverse division of the bacillar joints constituting those extremities, are animated during some time with an active motion, due to the existence of a flagellum. The latter is visible only with the highest magnifying power (Hartnack immersion objective No. 12).

The gonidia afterward gave birth to an irregular form (*Merismopædia*), which is soon transformed into a mass of *Zoogloeæ*, similar to a *Palmella*, and finally into regularly cylindrical tubes of various lengths.

The causes which have brought about the exaggerated development of *Crenothrix* in the Emmerin waters are evidently manifold. The soil was prepared by industrial dejections, especially those from distilleries, which discharge nitrates in abundance into the water-bearing stratum, at certain places very near the surface. The sources are, moreover, in the vicinity of swamps and ponds, like those of Tegel in the environs of Berlin.

Last winter having been relatively dry, the water-level was lowered about 5 meters. The rains of the spring and the beginning of the summer suddenly raised it, and carried with them the vegetable productions or the animals which had been developed in the humid earth.

While at Lille the *Crenothrix* was thus brought in abundance into the Emmerin reservoirs and the water-pipes, several wells at Tourcoing furnished balls of a fine Oligochæte worm (*Phreoryctes Menkeanus*), till then unknown in France.

Lastly, a portion of the aqueduct is dug in the aquiferous chalk; and it was thought needless to arch over that part; moreover, inlets have been pierced in order to increase by drainage-water the supply furnished by the springs. Every time that the flow of the water is made more rapid, in that part of the aquiferous layer a veritable aspiration is produced, which carries into the aqueduct the spores and filaments of the *Crenothrix*, which a slower and more complete filtration would have retained in the soil.

To remedy this scourge, we at first advised to do away with the latter source of contamination, against which it is comparatively easy to guard. But we believe that this palliation would be insufficient while the channels are sown with the innumerable spores of the Schizomycete. We shall doubtless be obliged to have recourse to filters of sand, similar to those recommended at Berlin by Zopf and Brefeld.

Towns establishing new systems of canals of potable water will do well, in order to avoid the *Crenothrix*, to take the sources in the deep strata, to avoid waters containing salts of protoxide of iron (necessary to the vegetation of this Schizomycete), and to prefer to subterranean waters the more aerated waters of lakes remote from all industrial establishments.—*Comptes Rendus*, July 31, 1882, xcv, 247–249. *Ann. Mag. Nat. Hist.*, Sept. 1882.

5. *Transactions of the Academy of Sciences of St. Louis*, Vol. iv, No. 2. St. Louis, Missouri, 1882.—This number contains among its scientific papers memoirs by C. V. Riley on N. A. Microgasters with descriptions of new species, and on new Tortricidæ; by F. E. Nipher, on problems in refraction, and magnetic determinations in Missouri in 1880; by C. A. Todd, on reversion of type in the digastric muscle of man; H. S. Pritchett, an ephemeris of Mars for the opposition of 1881; G. Engelmann, on the genus Isoetes in North America; E. A. Engler, on auroral phenomena of Sept. 12, 1881.

6. *Journal and Proceedings of the Royal Society of New South Wales*, 1881. Vol. xv. Edited by A. Liversidge, Prof.

Chem. and Min. Univ. Sidney. 1882.—The papers in this volume discuss subjects connected with the climate, geography, and botany of Australia, and give the results of extended astronomical observations. The analyses of epiphytic plants by Mr. Dixon on page 299 are from one of its articles; and also the note on the supposed subterranean drainage of Central Australia, on page 295. The astronomical memoirs are: On the elements of Comet II of 1881, by Mr. JOHN TERBUT, F.R.A.S.; on the spectrum and appearance of the same comet, by Mr. H. C. RUSSEL, F.R.A.S.; a paper of sixty-six pages on "New double stars and measures of some of those found by Sir John Herschel," by Mr. RUSSELL; and on the Transit of Mercury of Nov. 8, 1881, by the same observer. Mr. Russell states that about 746 of Herschel's stars have been re-measured, and 350 new double stars have been found. Some of the latter have afforded evidence of motion. 46 of Herschel's list have not been found.

7. *U. S. Commission of Fish and Fisheries, Part VII*, being the Report of the Commissioner, Prof. S. F. BAIRD, for 1879. 846 pp. 7vo, with many plates.—This Report, after details as to the special work for the year in the propagation and distribution of food-fishes and the study of the facts bearing on their habits, food, and causes of increase and decrease, gives to the country a large amount of information on these and related subjects from outside sources. Some of the headings of its chapters from European writers are the following: the Iceland herring fisheries; the herring's mode of life; the fisheries of the west coast of South America; the temperature, saltness, currents, etc., of the German seas with reference to fish support and propagation, and the habits of food-fishes; the pollution of public waters by refuse from factories; sawdust as a source of injury; foreign piscicultural establishments; and the raising of sponges from cuttings. It also contains a treatise on the sea-weeds of New England, with fifteen plates, by Prof. W. G. FARLOW, the ablest writer on the subject in the country, and a report on the gigantic squids and other cephalopods of the northeastern coast of America, by Prof. A. E. VERRILL, illustrated by forty-six plates.

OBITUARY.

LIOUVILLE.—The announcement of the death of the veteran mathematician, J. Liouville, founder and, for nearly forty years, editor of the Journal de Mathematiques, has been announced.

PLANTAMOUR.—The late director of the Observatory at Geneva, M. E. Plantamour, died recently.